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The Cabinet-Makers Sketch Book

A Series of Original Details,

FOR

MODERN FURNITURE

By

P. Thomson,

Author of the Cabinet-Makers' Assistant.

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P. Thomson. J. Scott.

TO

Charles Trotter Esq.r

EDINBURGH

THIS WORK

By kind Permission

DEDICATED

AS A MARK OF RESPECT

By his Much Obliged & Humble Servant

The Author.

DESCRIPTION OF PLATE,

HINTS FOR YOUNG TRADESMEN, No. I.

Fig. 1, on this Plate, represents a sideboard front, with a diagram explanatory of the method of delineating it. For the benefit of apprentices, we may here explain the system of working out the figure with the compasses, the practice of which will initiate the young artist into several processes of a like character.

The oval may be drawn in a variety of ways, but the diagram before us will show both the method of delineation and the rule for finding it. The circle, 1 to 7, is divided into equal parts, as the regulator of the figure. By placing the 1 higher and the 7 lower, or the reverse, the oval will be made long or flat at pleasure. The point of the compasses is first placed at 1 on the circle, the leg being extended to 1 on the large sweep, thus drawing a portion of a circle to the first dotted line on the right. Then sweep from 2, and extend the compasses as before, up to 7. The upper portion is done in the same way—extending from the lower 4 to the upper 4 all round to 1, where the circle intersects the dotted line. The dotted line from 4, up through the sweep, gives the list on the top.

Mouldings of this character are termed Roman, although, strictly speaking, a Roman moulding is produced by parts of circles, whilst Greek mouldings are formed of ovals. Now this figure is formed of parts of ovals, and, owing to its roundness, has been claimed by the Romans as altered by them from the Greek; like the Composite order of architecture, which is a compound of Corinthian and Ionic.

The small ogee below is divided into four equal parts, with the points on one line.

Fig. 2 is a perspective elevation of a portion of a chair. In delineating this, it is to be remembered that 18 inches is the ordinary height of a chair seat from the floor. First we must determine the size of the front, which is usually equal to the height. The front is then to be divided into four equal parts—that is, one part blank, one part the front of the chair, and the other two the side. At the upper corner, to the left, the dotted line, running three parts, cuts the depth of the back leg; the dotted line coming from the right to the centre, on the ground line, cuts the leg a second time. Generally, the point of sight is put 5 feet 6 inches high by the scale beneath the figure; but if this were done, it would appear to be suspended. In the figure before us, this point is only 2 feet 6 inches from the floor to the eye.

Fig. 3 is drawn on the same principle, adapted for cubes, such as wardrobes, sideboards, and cheffoniers. In the case of a wardrobe, the point of sight may be about five feet from the floor. To lay it down, first draw the four fronts; then, from the right corner on the upper line, draw the dotted lines. This done, the line from C to B is to be drawn, cutting the square of the blocks. Then raise the perpendicular, and, with the T-square, draw the horizontal line, showing the top. Afterwards draw a line from corner to corner on the shaded side, giving the centre of the blocks, and, raising the square, draw the top line.

DESCRIPTION OF PLATE.—CORNICES.

Fig. 1, on Plate, is well adapted for a bookcase of large dimensions. On a smaller scale it will answer well for a large wardrobe. It is, however, more suitable for the former; and as in a large library the cornices usually go up to the ceiling, it would, on this account, show to fine effect. The extent between G and the dotted line near the centre of the screw-nail, represents a piece of fir—the upper part being held on by the screw. On this is planted the top moulding of solid mahogany or oak. Beneath, the double line represents the portion which is veneered, down to the bead. Round, under this again, is another veneer, continued through the under curve as far as B, which is solid. The oval moulding is solid, and is planted on the fir, as also is the short length between the large moulding and bead. The bead itself is solid, and the succeeding longer, or frieze portion again is veneered. The under bead and portion at G is solid, to allow of working out the under hollow. The upper piece of fir, where the top moulding is planted on, is glued on before it is veneered.—See the dotted line cutting the veneer.

To delineate this, place the compass leg at A, and extend to A, sweeping round, to give the requisite size of wood for a blocking, which, as it is not seen, may be square. Next place the compass point at C, and extend it to C, and perform the same operation, and afterwards the like from B to B. Then, for the large mouldings, place the compasses at D, and extend to D, then from E to E, on the sweep. We are thus explicit, in order that the young apprentice may see his way perfectly clear.

In commencing to delineate this cornice, the perpendicular and horizontal pieces of fir must first be framed; then plant on B first, afterwards the large moulding, then the two beads and C below. The top moulding and three beads may be gilt.

Fig. 2 exhibits the groundwork of an S, and forms the plan of an oval. After laying down the perpendicular and horizontal lines, describe the three circles. The intersecting lines cut the outer circle, for the start of the oval. The compass point is to be placed at the top of the circle, on the perpendicular line—extending the leg to the top of the small circle, sweeping round for the start of the oval.

To form the oval, the compass point is to be placed at the upper edge of the top of the small circle, extending to the under edge of the under small circle; the point is then to be placed on the cross line, sweeping round on the horizontal line, which gives the extent of the flat sides of the oval, and the same on the side.

Fig. 3 very nearly resembles fig. 1, and requires little description. The compass point is to be placed at A, and extended to A, outside, for the sweep. The same must be done from B to B, and C to D. This cornice will answer well for a rich bed in mahogany. Either of the two, reversed, will give the base for a fire-screen, stand, or other article of a similar class.

Fig. 4 is a diagram to give the height above a cornice in a room, whether for a wardrobe or bed. It affords its own explanation.

DESCRIPTION OF PLATE,

HINTS FOR YOUNG TRADESMEN, No. 2.

This sheet will afford very good practice for beginners. Figs. 1, 2, and 3, are very similar to each other; they each exhibit ample scope for design and proportion. In fig. 1, the lines of one moulding are carried round to form another totally different. In the numeral and literal references, 1 is the start, A adjoining it being twice its width, whilst 2 is half the width of 1. B, Is half of A, and 3 half of 2. Particular attention is necessary for 1, 2, 3, and 4, which are all lists. Referring to the height of 1 above the horizontal line of A, B, C, 2 must be carried half way up, and 3 and 4 the same. The dotted lines indicate the centre for describing the circle. The sections at the ends are formed into squares by the dotted lines, for the purpose of measuring the distance back to each member.

Fig. 2 is the corner of a panel, usually considered a difficult piece of work. The cutting of the inside circle is the part to be carefully looked after. If a panel corner is drawn from the outside without just attention to the breadth of moulding, great risk of spoiling the work is incurred. Frequently a marble slab is formed to a fine outline, the section of the moulding only being given; then, on commencing to form the margin, it will not work, and great alteration is necessary to bring it in. The dotted lines give a clear explanation of how this is done.

Fig. 3 differs little from the last. The three figures formed by the dotted lines give the proportions.

Fig. 4 is an example of hand-sketching—a sideboard being chosen for the purpose. Having fixed on the scale of the figure, the elevation must first be drawn, dividing it into four equal parts. The dotted line must then be drawn from A, on the left corner, to D, cutting C, giving the breadth of gable. The perpendicular is then to be raised from C to F; then draw from E on the right to F and C, for the height of the end of back, and from F to G for the breadth of top.

DESCRIPTION OF PLATE.—SIDEBOARD DETAILS.

In fig. 1 are shown the dotted lines for working the compasses round the sweeps of the large moulding. A, Is the top above the drawer. B, Is first worked to fit the moulding, and is afterwards shaped as shown, and glued on the moulding. This detail is ¼ inch thick when finished.

Fig. 2 is treated in a similar manner. The ogee moulding is veneered lengthways, and the drop is planted on after the veneer is polished. The two vertical dotted lines in the outline, or profile, show the drawer front, and the cross line from A to the lower part of D is the drawer front.

Fig. 3 very closely resembles fig. 1. The three points are clearly shown by the dotted lines; so also is the drawer front.

In fig. 4, the only difference is the carved ornaments on the front at B, which is first fitted on the large moulding, and then carved. The outline, B C, is the section.

Fig. 5 is a truss in the same style, intended to suit fig. 3. It may either be pierced or sunk, but is shown sunk. Of course, in this view, only a single pendant is shown, but there are four in reality, turned from beneath the first bead and list. The flowers may be planted on, and about half the breadth of the front of the truss at the top, and a quarter of the breadth at the under side, yet as free and graceful as possible.

DESCRIPTION OF PLATE.—BED AND DETAILS.

The end of this bed is the only important feature. The cornice is not so high at the sides and the end next the wall. The curtain at the end is higher than at the sides, as shown. The part of the curtain at the edge of the post is fixed, the other portion, working out on rings, going into the hollow on a straight rod, which is concealed under the cornice. For the covering of the cornice below, there is a piece of flat wood which carries the hollow right through. On the sides, the curtain works on a rod to the centre, or even to the head of the bed. The pillar is veneered, and goes up through the cornice by means of a round tenon. The mouldings are all sunk in after the pillar is cleaned off, and then the ornaments are fitted on. Bay wood is the best for the pillar, veneered with very rich Boa Constrictor mahogany, or myrtle. The moulding and ornaments to be of the same colour of wood, but plain, as they are well opened up. The footboard demands our attention only in details. Its section is exhibited at G, H, J, K, and L. The cornice again is shown on a large scale at A, B, C, D, and E.

ADVERTISEMENT.

THE Publisher, desirous to do everything in his power to render the SKETCH-BOOK, if possible, still more worthy the extensive patronage already bestowed upon it, has induced Mr. Thomson to visit Paris, for the purpose of inspecting the various Manufactories and Collections of Furniture in that capital, so celebrated for its taste in the Decorative Art. Mr. Thomson is now in London, where there is at present a rich field presented to the designer, in the collection of furniture from all parts of the world, to be found in the Great Exhibition; amongst which we see every variety of taste in designing, combined with the utmost skill in execution. Subjoined is copy of a letter received from Mr. T. during his stay in Paris:—

DRAKE'S ENGLISH HOTEL, RUE ST. HONORÉ,
Paris, 18*th September*, 1851.

MR. MACKENZIE,

DEAR SIR,

Since my arrival in Paris I have visited Versailles, and most of the public places here, and have occupied my leisure moments in making rough outlines of some of the most striking articles I have seen. The grandeur of the palaces and churches, especially the Magdalene, far exceeds anything I had ever conceived; and I am certain my visit to this place will be suggestive of many ideas that will be of benefit to my new work.

I intend to return to London in a few days, and shall remain there till the close of the Great Exhibition. You therefore may expect me in Glasgow about the middle of October.

I am, Dear Sir, yours truly,

P. THOMSON.

THE

CABINET-MAKERS' SKETCH BOOK.

LINEAR PERSPECTIVE.

CHAPTER I.

1. LINEAR PERSPECTIVE may be defined to be the drawing of objects in their exact proportions, with respect to height, length, and breadth, as they appear to the eye when placed in any position. This may be illustrated by placing a pane of glass, or other transparent substance, betwixt the eye and an object, and by keeping the eye steady, and tracing the different lines upon the object; if these lines be distinctly marked on the transparent plane, there would be a *linear perspective* view of the object.

2. It is necessary for the person commencing to learn perspective—if he has not got a previous knowledge of mechanical drawing—to understand the use of the instruments commonly used. We will here, in the first place, explain some of these, and show the manner of using them.

The *drawing-board* is generally made of deal, of a size according to the intended use. We would here recommend one for drawing perspective of about two feet nine inches, or three feet long, by two feet or two feet four inches broad, made of 1 inch or 1¼ inch stuff, neatly planed and clamped at the edges to keep it from warping. The paper might be fastened upon it, either by drawing-board pins, which is a very good and the most expeditious method, or by sealing wax, or by paste, which is done in the following manner:—Having cut the paper to the size required, wet the back of it with a sponge dipped in clean water, passing it over several times, and leaving it a short time till the water is absorbed, and the paper lies flat; run a rim of paste round the edge, about three quarters of an inch wide; then turn the wetted side of the paper downward on the drawing-board, and press the pasted rim close to the board with a paper knife, or some hard substance, pressing as much of the paste out as possible, that the paper may adhere firmly to the board. The face of the paper should be then wetted in the centre with a sponge, taking care not to pass it on the pasted rim: without this precaution, the centre would be dry before the edges, and the paste would not hold.

The best sort of drawing-boards are those made in a panel form: in these, there is an outside frame rebated on the inside, into which there is a moveable panel fitted, also rebated, to allow of the panel coming nearly flush with the upper surface of the frame. The paper is placed upon this panel, and then put into its place, where it is fastened by two pieces of wood in the back. This is undoubtedly the best sort of drawing-board, as it keeps the paper stretched, and answers well for drawings which have a deal of minute work about them, and also for colouring.

The next instrument is the T *square*, which is so well known that we would just recommend it to be made straight and strong, not to bend when drawing near its end; those made with a

screw, for drawing lines at any inclination, are most preferred. There are also small pieces of mahogany of a right-angled triangular form, called *set squares,* which by moving along the edge of the T square, lines can be drawn at angles for which the squares are made—those with 45° and 60° are very useful.

Compasses are very useful instruments in mechanical drawing. They should be fine pointed, and move freely at the joint, which should not, however, be too slack, for then a little compression might move them from their position. Those with fixed legs are called dividers. When the moveable leg is taken out, there is a leg which can be put into its place, having a piece of lead pencil fastened into it, for drawing circular lines in lead, and also another for circular ink lines.

Drawing-pens are very useful instruments for drawing lines in ink, after being marked out with lead. The handle is made mostly of brass or ivory, having two steel prongs on the one end, which can be brought close, or widened (betwixt which the ink is placed), by means of a screw, for drawing the lines fine or broad. There are also *bow-pens,* for drawing small circles in ink, which are very useful, and similar ones for drawing lead lines.

Parallel rulers are for drawing parallel lines: they are generally made of two pieces of wood, connected by two pieces of brass, fastened to them near the ends, allowing the wood to move freely: by holding on or pressing upon it, the other can be moved, and it is still held in its parallel position by the pieces of brass. Parallel rules moving on rollers are to be preferred.

These instruments, with scales, and a few others occasionally used, are those employed in mechanical drawing; those used in perspective will be described farther on. It may be remarked, that there are cases or boxes of instruments, containing compasses, drawing-pens, scales, &c., of different prices, from a few shillings to a number of guineas, to be got in almost every town of note in the three kingdoms—the student, by seeing them applied, will learn their use far better than by a written description.

3. It is presumed that the student is acquainted with practical geometry—raising perpendiculars, describing squares, triangles, circles, ellipses, pentagons, hexagons, &c.; if not, we would recommend him to learn that in Bonnycastle's Mensuration, or some other work, as there are many, and it would therefore be useless to enter upon the subject here.

4. There are five ways in which mechanical drawings are generally done:—1st, The *ichnographic* or *ground plan* of an object is the seat of the different parts, showing their correspondence, situation, and magnitude, without any reference to the height. 2d, The *orthography* or *elevation,* which is the appearance any object would present if an eye could view every part perpendicularly. 3d, *Sections*—these are cuts made through the object, showing its internal arrangements. If the section be parallel to the front, it is called a *longitudinal section,* and if from front to rear, a *transverse* or *lateral section;* any other is called an *oblique section.* 4th, The *scenographic*—that is, the representation of objects as they appear to the eye when in any position—or the *perspective view.* The scenographic is better applied to the perspectives of objects, as houses, for instance, when scenery is introduced. 5th, The *development*—this is the representation of any circular, elliptical, or polygonal figure, &c., when taken and spread out upon a plane, thereby giving the appearance of an orthographic projection or elevation. Having gone thus far, we will begin now and explain some of the fundamental parts of the science.

Fig. 1.

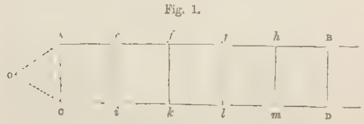
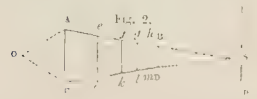


Fig. 2.



5. If a person stand at the middle of one end of a long road, which is supposed horizontal, straight, and of a uniform breadth, the sides will seem to approach nearer and nearer to each other as they are farther from his eye; and if the road be very long, the sides of it at the farthest end will seem to meet, and there an object that would cover the whole breadth of the road, and be of a height equal to that breadth, would appear to be a mere point. If A B and C D, fig. 1, be two parallel sides of a road, and O the place of the observer—suppose

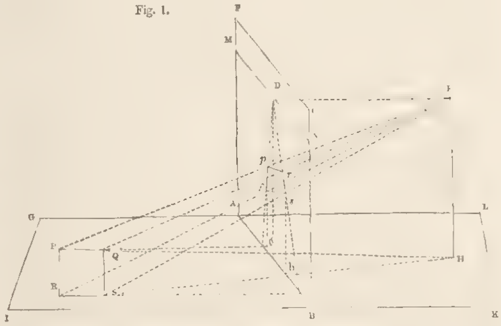
the road to be divided into squares, A C *i e*, *e i k f*, &c., the person standing at O will see these two sides as if they were gradually approaching towards one another, as in fig. 2; and the squares will seem to diminish in size as they are farther from the eye—so that the first square, A C *i e*, fig. 1, will appear as A C *i e*, fig. 2; the second square, *e i k f*, fig. 1, will appear as *e i k f*, fig. 2; and so on till the last square, which would vanish into a point, as S in fig. 2, where A S and C S meet.

6. The point, S, where the parallel sides of the road seem to meet, is called the *point of sight*, and is still opposite to the observer, and at the height of the eye. The place where the observer's eye is placed is called the *place of the observer*, or the *point of view*. The line, P S, passing through the point of sight, is called the *horizon*.

CHAPTER II.

1. In the annexed figure it is intended to show more particularly the principles upon which this kind of perspective depends. G I K L is called the *ground plane*, upon which there is a square, P R S Q, to be drawn in perspective; F A B C is the *plane of the picture*, upon which the representation is to be made; E is the *point of view*, sometimes called the *point of sight*; it is the place of the observer's eye, and hereafter shall be called the *point of view*, and the *point of sight* shall be applied to the point opposite the eye in the horizon, to which lines and planes perpendicular to the plane of the picture converge. M N is the horizon of the picture, or the representation of the meeting of the sky and water, if an observer were looking at the ocean; and it may be remarked that the horizon, M N, is still on a level with the eye. If a sketch were made on the top of a mountain, the horizon would then be high up; and if made from a valley or some low place, the horizon would then be low down: and in every linear perspective drawing, there must be a *horizon* or *horizontal line*. We might suppose M N was the representation of the line or visible connection of sky and land; and this apparent meeting or line, though below the level of the eye, is still put at the eye's height, as the distance from the eye to the picture is so small, that there can be no sensible difference in taking the horizontal line, M N, at the height of the eye.

Fig. 1.



E D is perpendicular to the horizon, M N; the point, D, is called the *point of sight*; the line, A B, in which the plane of the picture and the ground plane intersect, is called the *section line*: now, if lines be drawn from P Q R S to E, the points, *p q r s*, where these lines intersect the plane of the picture, being joined, will form the perspective representation of the square. The operation just mentioned may be said to be of no very great use in drawing perspective, as a transparent plane cannot always be held before an object, for perspectives are made of houses, bridges, machinery, &c., before any of them are built or constructed; indeed, if perspective consisted only in this, it were very contracted, and therefore of no great importance. We see, therefore, recourse must be had to other means. The point, H, in the ground plane, directly under the eye, is the point to which the lines are drawn from the object; we have drawn two in the diagram, as more would only have caused confusion: and from the points, *a b*, where they meet the section line, we raise

perpendiculars until they meet lines drawn to the point of sight in *q s*, from the points where P Q and R S meet the section line produced. If two other lines had been drawn from P R to H, and perpendiculars raised as before, they would have marked out *p r;* if then, *p r, q s,* &c., be joined, there would be formed *p q r s,* the perspective representation. This will be better understood by the following, with respect to the square.

2. *To put a square in perspective.* Let A B C D be the square which is to be drawn, and E the point of view. We will suppose, in the first case, that the plane of the picture, or the section

Fig. 2.

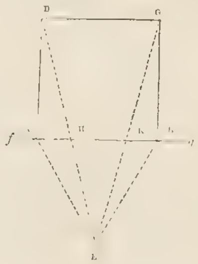


Fig. 3.

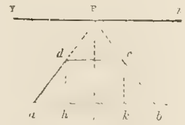
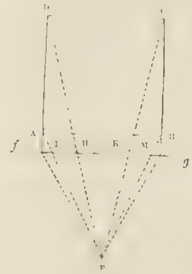
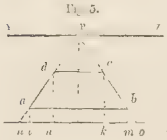


Fig. 4.



line, *f g*, coincides with the side, A B, of the square, and that the point of view is exactly opposite the side, A B, of the square, the visual rays, E D, E C, are drawn, making the side, D C, appear equal to H K. The side of the square is eight feet, and is laid down at the scale of an eighth of an inch to the foot. In fig. 3, *a b* is made equal to A B, fig. 2, because it touches the section line or plane of the picture, and therefore it is the real size. Draw the horizontal line, Y Z, at the height of the eye, about five feet four inches, and as the observer stands opposite the middle of the side, *a b*, the point of sight, P, will be also opposite the middle; join P *a*, P *b*, make *h k* equal to H K, and put half on each side of the central line, and draw the perpendicular *h d*, *k c*, and join *c d*—then *a b c d* will be the perspective representation.

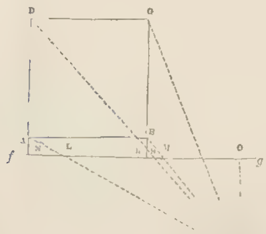
Fig. 5.



3. In the second case we, will suppose that the plane of the picture does not touch the side of the square, but the observer is still standing opposite the middle of the side, as in fig. 4.

Draw the visual rays, E A, E D, E C, E B; then the apparent sizes of D C and A B will be H K, L M; then, in fig. 5, draw the base line *n o*, and at the proper height the horizontal line Y Z; leave off *h k*, *l m*, *n o*, respectively equal to H K, L M, A B, one half on each side of the central line; join *n* P, *o* P, and draw the perpendiculars, *l a*, *h d*, *k c*, *m b*, and join *a b*, *c d;* then *a b c d* will be the square.

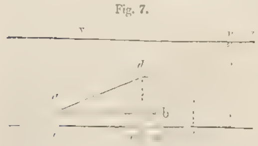
Fig. 6.



4. In the third case, we will suppose the observer stands to one side, and that the plane of the picture does not coincide with the side of the square, the plane of the picture being still parallel to the side of the square, as in fig. 6.

Let the visual rays be drawn as before, and let E O be the principal one, or the one directed to the point of sight. In fig. 7, let *n o* be the base, and Y Z the horizontal line, P the point of sight, *o* P the principal visual ray; leave off *o n*, *o l*, *o r*, &c., equal to O N, O L, O R, &c.; join *n* P, raise the perpendiculars, *l a*, *h d*, &c., and join *a b*, *c d;* then *a b c d* is the square. Now, the attentive reader will easily see the connection of this method with that mentioned in description

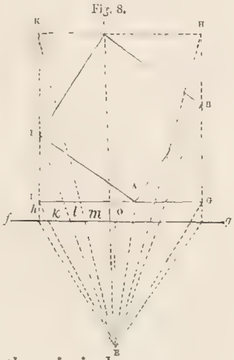
Fig. 7.



of fig. 1. The point, E, in figs. 2, 4, and 6, is the same as H, fig. 1, which is the point perpendicularly under the eye on the ground plane. The lines, though drawn from the object to it, mark out on the section line the apparent length and breadth virtually the same as if they were drawn to the point of view. Again, in fig. 1, from the points where the visual rays cut the section line, perpendiculars were raised, meeting lines passing to the point of sight; the same is adopted in figs 3, 5, and 7, where the perpendiculars are also raised, meeting lines passing to the same point.

In the three examples which we have given with respect to the square, and in other subsequent examples, we might have done with one figure, but we would like to impress these first principles upon the mind of the reader in as easy a manner as possible; we have therefore adopted two figures, that it may be the better understood. It is evident, that if A B C D, in figs. 2, 4, and 6, had been a right-angled parallelogram or rectangle, its perspective could have been as easily made; and if A B, in fig. 6, had touched the section line, it would have been easier.

Fig. 8.



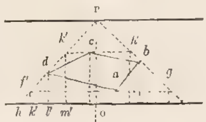
We might also mention, that if A B C D had been a pavement divided into squares, or of it were a square garden, or a rectangular one with straight walks and flower plots, it could be very easily drawn by going upon the same principle which we have adopted.

5. There is still another case with respect to the square, viz.:—when the section line is oblique to all of the sides, as in fig. 8.

Draw F G parallel to the section line, as also K H, and draw the perpendiculars, K F, H G; draw the visual rays, E F, E D, &c., and E O, the principal one.

Now, let the base line and also the horizontal one be drawn, fig. 9, as before, and also f' g' h' k', the perspective representation of F G H K, and let O P correspond with E O the principal visual ray; leave $o\ h'$, $o\ k'$, &c., equal to $o\ h$, $o\ k$, &c., and let the perpendiculars be raised till they meet the lines passing to the point of sight, &c., marking out the points, f', k', &c., corresponding with those in fig. 8, as also $a\ b\ c\ d$, which points being joined, mark out the perspective representation.

Fig 9.



We have drawn all the lines necessary on the figures, so that the student will clearly see the method of proceeding.

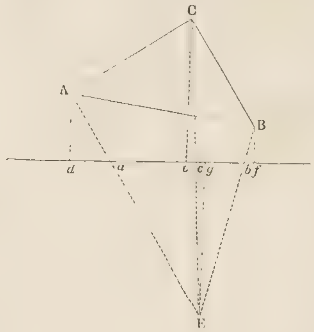
CHAPTER III.

1. It will be seen, by reference to the preceding chapter, that in the three cases of the square which were taken into consideration, in which the plane of the picture was parallel to two of its sides, these sides were parallel to one another in the representation, and the other two sides converged to the point of sight; but (in 5) where the sides were oblique to the plane of the picture, it was seen, that in the representation, the two sides, which in the former cases were parallel, are no longer so, but converge to a point on the horizontal line, whilst the other two converge to another point also on the horizontal line. This will take place if they be accurately constructed; whereas, those lines which circumscribe the square, converge to the point of sight, or are parallel to one another, as the case may be. These points to which the lines converge are called *vanishing points*, and are in general on the horizon.

2. Linear perspective is of two kinds. The first is called *direct* or *parallel*; it is the same as described in Chap. II. This is the easier sort: it is so called, because, in the face of the object (which is parallel to the plane of the picture) in the representation, the horizontal lines are parallel,

whilst on the end or flank these lines converge to the point of sight. The second kind is called *indirect,* because those lines which, in the former case, were parallel to one another and to the horizon, in this are not, but converge to the vanishing point; and also those on the end or flank, which in the former case converged to the point of sight, in this they converge to a vanishing point.

Fig. 1.



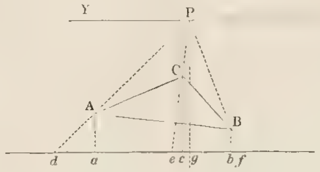
As the two kinds are differently managed, and the *direct* being the easier, we shall consider it first:—

3. By proceeding nearly in the same manner as that adopted (in 5), we could, by direct perspective, put the plan of any object into this sort of it when the figure is bounded by right lines; and, as will subsequently be seen, the plan of any figure, no matter by what sort of lines bounded. Now, that we may be perfectly understood in this, we will put first a triangle, and then any rectilineal figure, by this method in o perspective.

4. To put a triangle into perspective by the direct method.

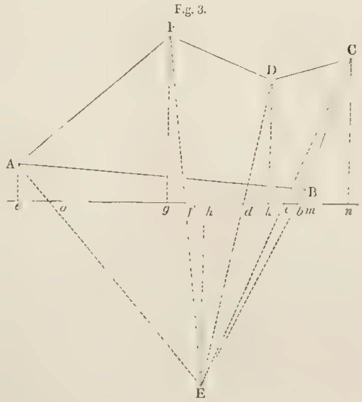
Let A B C, fig. 1, be the triangle, *d f* the section line, E the point of view. Draw the visual rays, E A, E C, E B, cutting the section line in *a c b;* draw also the perpendiculars, A *d,* B *f,* C *e,* and the principal visual ray, E *g.*

Fig. 2.



In fig. 2, draw the base line, *d f,* at the proper height, also the horizontal line, Y Z. Let *g* P represent the principal visual ray, proceeding to the point of sight, P; leave off *g d, g a,* &c., equal to *g d, g a,* &c. Draw lines to the point of sight, P, from *d, e, f,* and raise perpendiculars from *a, b, c,* to meet these lines respectively, and they will mark out the points, A, B, C, which being joined, give the required representation.

Fig. 3.



5. To put any rectilineal figure into perspective by the direct method.

Since any rectilineal figure is composed of triangles connected with one another, it follows that the figure can be easily put into perspective when the method of putting the triangle is known.

Let A B C D F, fig. 3, be the rectilineal figure, *e n* the section line, E the point of view; draw the visual rays, E A, E F, &c., and the perpendiculars, A *e,* F *g,* &c.

Then, in fig. 4, draw the base line, *e n,* the horizontal line, Y Z, and take the point of sight, P, and let P *h* be the principal visual ray. Leave off *h e, h a,* &c., respectively, equal to *h e, h a,* in fig. 3, and draw the lines *e* P, *g* P, *k* P, *m* P, *n* P, to the point of sight, and from the points *a, f,* &c., draw perpendiculars until they respectively meet the other lines in the points A, F, &c.; these points being joined will give the representation.

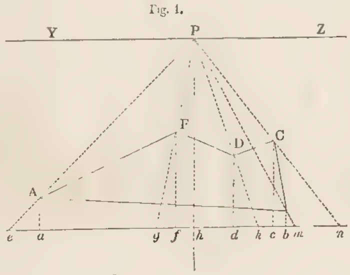
6. Having now shown the method of putting the plan of any object, when bounded by right lines, into this perspective, before proceeding to the consideration of objects with regard to height, we would recommend the reader who may read this, and who would wish to become acquainted with this useful branch of science, to make all the figures two or three times the size here shown, and afterwards progressively introduce others which the fancy may dictate—such as quadrila-

terals, pentagons, hexagons, &c.—as a short practice will sooner and more efficiently bring it home to the mind than any descriptions, no matter how well and how easily written.

We are well aware, from a very particular examination of the principles of direct perspective contained in various works, such as Ferguson's, Hayter's, and a voluminous work by a French Jesuit, translated by Chambers, &c., &c., that the way we treat it is different from theirs a little; yet ours is conducted in the same manner as that adopted in indirect perspective—with this difference, that in the latter there are vanishing points to which the lines converge, whereas it is to the point of sight they converge in the former, as described by writers on this branch; and it is our opinion, that it is founded upon rational principles, and deducible from mathematical precedents, and easy in its application.

7. With respect to the distance the observer should stand from the object, some lay it down as a rule to stand off the distance of the two visible sides taken together—as, if the object were a house, to stand off a distance equal to the length of the two sides which are seen; whilst others consider this too little, and we think it answers better to stand farther off than this—say about as much, and one-fourth or one-third as much more. It greatly depends on taste; but there are some positions which give better perspectives than others, as is very soon learned from practice. Others stand off such a distance as the angle comprehended between the extreme visual rays which proceed to the object, may be about 60° as the angle, A E B, in fig. 2 of Chapter II.

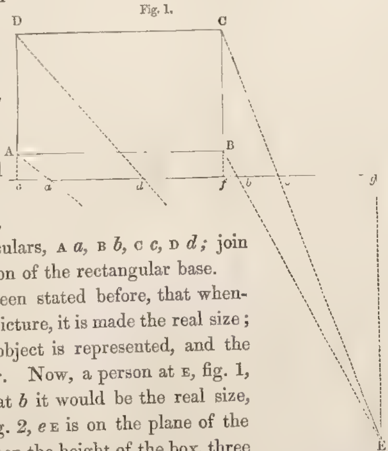
Fig. 1.



CHAPTER IV.

To put a cube, parallelopiped, or a box in perspective.—Let the dimensions of it be 7 feet long, 4 broad, and 3 high. Make the plan, A B C D, fig. 1; draw the section line, *e g;* take E, the point of view at a distance, equal to A B and B C together, from the object, and draw the visual rays, E A, E B, &c., and produce D A, C B, to *e* and *f*.

Fig. 1.



In fig. 2, draw the base line, and at the proper height, say about five feet four inches, the horizontal line, Y P; take the point of sight, P, leave off *g e*, *g a*, &c., equal to *g e*, *g a*, &c.; in fig. 1, draw *e* P, *f* P, to the point of sight, P, and raise the perpendiculars, A *a*, B *b*, C *c*, D *d;* join A B C D, then A B C D is the perspective representation of the rectangular base.

Here we would remark more fully what has been stated before, that whenever any part of an object touches the plane of the picture, it is made the real size; that is, with respect to the scale by which the object is represented, and the smaller, the greater the distance from the observer. Now, a person at E, fig. 1, would see an object at D, smaller than at B; but at *b* it would be the real size, because it touches the plane of the picture. In fig. 2, *e* E is on the plane of the picture, and perpendicular to the base line, *e g;* if then the height of the box, three feet, be left off on *e* E, and a line drawn to the point of sight, P, the point, F, where it cuts the perpendicular, A F, will give A F the perspective height required, the parallel, F G, and also the

line, G P, intersecting the perpendicular from C in H, and then draw the parallel, H L; this then will give the required representation.

A perpendicular from *f* would have answered equally as well for the height line. If the

Fig. 2.

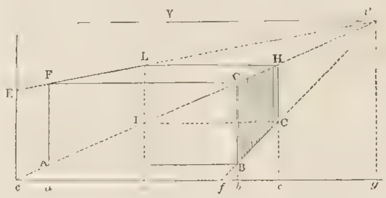
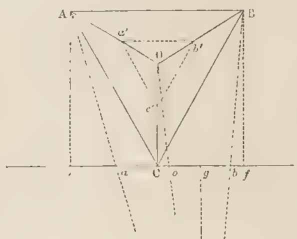


Fig. 3.



object were a cube, its perspective would be found in the same way; and if the object touched the section line, its perspective would be still more easily found.

2. *To put a pyramid in perspective.*—Let it be a triangular one, each side of which is six feet, and the perpendicular height seven.

Let A B C, fig. 3, be the plan of the pyramid, O the centre, take E the point of view, and let the section line be parallel to side, A B, and touch the angle, C; draw the visual rays, and the principal one, E *g*, and the perpendiculars, A *e*, O C, B *f*.

In fig. 4, let P be the point of sight, Y Z the horizontal line, and *e g* the base line; leave off *g e*, *g a*, &c., equal to *g e*, *g a*, &c., in fig. 3; and because the lines, A *e*, O C, B *f*, are perpendicular to the section line in fig. 4, they will converge to the point of sight. Raise

Fig. 4.

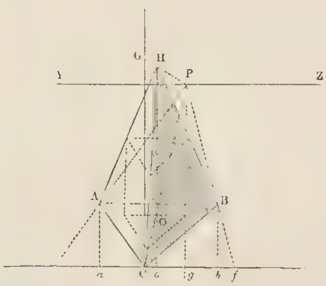
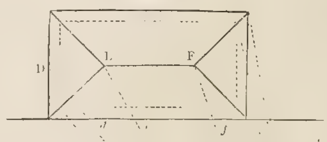


Fig. 5.



the perpendiculars, A *a*, O *o*, B *b*, and they will give the points, O, A, B, the latter two of which being joined with C, gives the perspective of the base. Draw the perpendicular, C G, and leave off the height on it, seven feet, and draw the line, G P, to the point of sight, P: the point H, where it cuts the perpendicular from the centre O, is the vertex of the pyramid, which being joined with A, B, and C, gives the required representation. Only one side of it is seen when the point of view is opposite the middle of that side.

If A B C, fig. 3, were the plane of the base of a frustrum of a pyramid, and the dotted lines *a′ b′ c′* its top, its perspective would be found by putting the small triangle in perspective, as in fig. 4, and raising perpendiculars until they would meet the lines from A B and C to H, and then joining these points for the top, the base being previously formed as before.

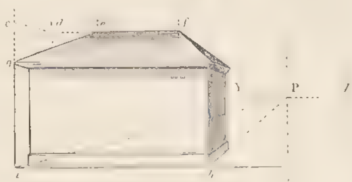
It is evident from this, that any pyramid, whether triangular, rectangular, octagonal,

&c., or any frustrums of these, might in this manner be put in perspective, and also any prism.

3. *To put the block of a house in this perspective.*—In fig. 5, let the dotted lines indicate the outline of the walls, and the drawn lines the roof; the section line touches one side of the roof.

In fig. 6, P is the point of sight, Y Z the horizontal line, *a c* the height line, which touches one corner of the roof, *a b* the base line. The roof being the most difficult part, is done in the following manner:—The height, *a g*, to the spouting, is left off on *a c*, and its depth (five or six inches), and then two lines are drawn horizontal to the other side, and then from its extreme projection, which is found by plan lines, two lines are drawn to the point of sight. Now the height to the under side of the projection of the roof must be perspectively laid off, and it, together with the line of projection, and two short lines (one at *g* to the point of sight, the other at the remote corner horizontal), will show the *soffit* or under side of the projection of roof. For the height, leave off *a c* equal to the whole height, and run a line to the point of sight, cutting a perpendicular in *d*, which corresponds with D in fig. 5, and then a horizontal line, cutting the perpendiculars in *c* and *f*, which points again with E and F, fig. 5, and then draw lines to the extremities of the roof. The plinth may be easily put round the two sides, and the rest of it is easy.

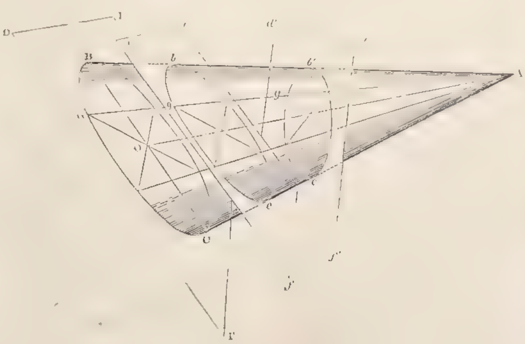
Fig. 6.



CHAPTER V.

The drawing of curves in perspective, or curvilinear perspective, is more complex, and therefore more difficult, than that of right-lined or rectilinear perspective. The ellipse, hyperbola, parabola, &c., are seldom drawn in perspective; if so, the method of points, which are here pointed out for the circle, are equally applicable with respect to them. It is evident, that if the eye be directly over the centre of a circle, or in a line drawn perpendicular to its plane from the centre, its perspective representation will also be a circle; for, if the plane of the picture be put betwixt the eye and the original circle, and of course parallel to it, and lines drawn from the eye to the circumference of the original, these lines would evidently trace out a circle on the plane of the picture.

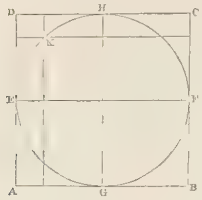
Fig. 1.



Let D E F be a plane on which there is the circle, B G C, and O its centre, and O A the principal visual ray, passing through the eye, A; now, if rays be supposed to pass from every point of the circumference to A, these rays will form a cone, and every plane, parallel to the original D E F,

will be cut by these rays in a circle. If the plane, *d e f*, be parallel to D E F, and which might represent the plane of the picture, it will be cut also in a circle, as *b g c*; it will be greater or less than the original, according as it is farther off, or nearer to the eye, than it. In mathematical language, the diameter of this circle is to the original in the ratio of their distances.

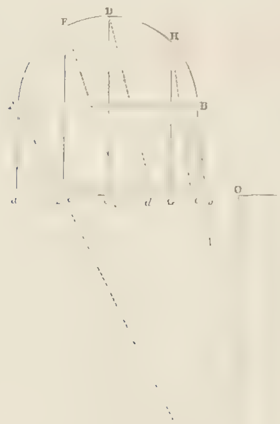
Fig. 2.



Now, suppose another plane, as *d′ e′ f′*, intersects the cone of rays, but is not parallel to the original, it can be proved mathematically that *b′ g′ c′*, the perspective representation, will be an ellipse: it may be said the perspective of a circle is generally an ellipse.

If the eye of the observer be in the same plane with that of the circle, it will then appear as a straight line. A familiar example of this may be seen in a tea-cup, which, if a person hold in his hand, with the eye over the middle of it, will then appear as a circle; and if it be gradually turned round, it will assume the forms of ellipses, becoming more and more elongated, until finally it appears as a straight line, or it will assume appearances of ellipses of every possible eccentricity, from zero, or the circle, to one of the diameters, or the straight line.

Fig.



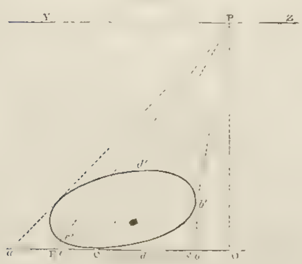
2. *To put a circle in perspective.*—Let E F G H be a circle; draw two perpendicular diameters, E F, G H, and tangents at their extremities; then A B C D is a square.

If this square be put in perspective by the method previously pointed out, and the points, F, G, H, E, found, there would then be four points given, through which the circle must pass. This way will do where great accuracy is not required, but the number of points may be increased. The point, K, may be taken in the curve, and through it parallels to the sides; the perspective of K may then be found, and also in the same way any number of points as may be thought necessary, and then the circle traced out with the hand.

The following way finds eight points which perhaps might be accurate enough for general use.

Let A C B D be a circle, say four feet in diameter, and M the point from which it is viewed; draw the two diameters, A B, C D, perpendicular to one another, and such that C D is perpendicular to the section line, O E, which in this case touches the circle. Draw any two lines, E F, G H, parallel to C D, and cutting the circle; and draw lines from the various points to the point of view. In fig. 4, draw the line O E, and parallel to it Y Z, the horizontal line, and take into it P, the point of sight; leave off O E, O C, &c., *o e*, *o d*, &c., equal to O E, O C, &c., and *o e*, *o d*, &c., in fig. 3.

Fig. 4.



Because E F, C D, are perpendicular to the section line in fig. 3, in fig. 4 they will run to the point of sight, P, and then perpendiculars from *e d*, &c., will meet these lines in points *e′*, *d′*, &c., which mark out points in the circumference of the circle; and with a steady hand the perspective of the circle may be traced out after the rest of the points have been found in the same manner.

3. In a former chapter, the method of putting any rectilineal figure into perspective was shown, and by the method of points, as applied to the circle, any curvilineal figure may also be put into it; and as all figures on the same plane, no matter how irregular they may be, are bounded by straight lines or curves, (or the figure may be called *mixtilineal,*) it is evident that the methods for these two conjoined will be the mode of proceeding in general cases.

4. *To put a cone in perspective.*—Let A B C, fig. 5, be the plane of a cone three feet in diameter at base, and four feet high. Let F O be the section line, and E the point of view, eight feet from the cone; let D be the seat of the vertex; draw D F perpendicular, and draw the visual ray, E D.

Fig. 5.

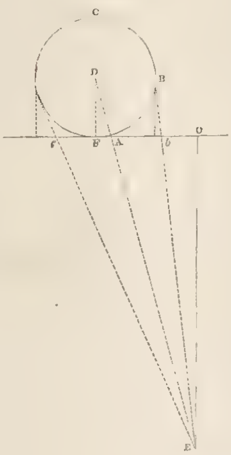
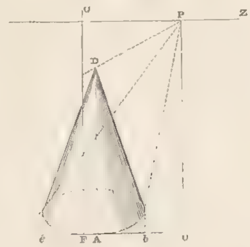


Fig. 6.



In fig. 6, let Y Z be the horizontal line, P the point of sight, and O F the base line; the base of the cone being a circle, it must therefore be first put into perspective. Make O F, O A, equal to O F, O A, in fig. 5, draw the perpendiculars F G, A D, and leave off the height of the cone on F G, four feet, and from this point draw a line to P; then where it cuts perpendicular from A in D, D will be the vertex; then draw tangents from D to the curve—they will form slant sides of the cone. Or if O *e*, O *b*, be made equal to O *e*, O *b*, in fig. 5, and perpendiculars drawn, they will touch the curve in two points, to which, if lines be drawn from D, they will form the slant sides of the cone. In fig. 5, *e b* is the representation of the apparent size of the diameter of the circle, found by drawing lines to represent visual rays to touch the circle.

5. *To put a cylinder in perspective.*—The top and bottom are equal circles; the bottom circle

Fig. 7.

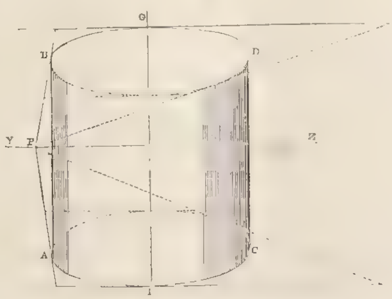
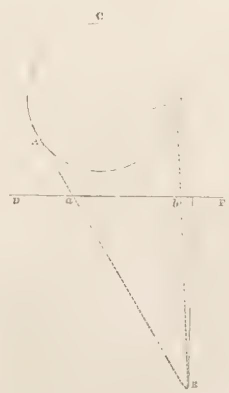


Fig. 8.



can first be put into perspective, and then the top one directly over it. The plane of the picture touches the cylinder; F G is the line on which the height is laid off; Y Z is the horizontal line, and P the point of sight, as before. The two lines, A B and C D, may be made to touch the circles in A B, and C D; or these points may be found by the method shown in the last example.

6. *To put a globe in perspective.*—If the plane of the picture be perpendicular to the visual ray, passing to the centre of the sphere, the representation will be a circle; but if it be not

perpendicular, the representation will be an ellipse. Let A B C be the plane of the sphere, E the point of view, and D F the section line. Now, if lines be drawn from E to touch the sphere in A and B, A B will be the apparent size of the diameter, and *a b* its representation. A section of the sphere through A B will be a small circle of the sphere, of which A B is the diameter; and all the visual rays from E to touch the sphere, will touch the circumference of this circle. The perspective of the globe will then be found by putting this circle into perspective by the method previously shown.

PRACTICAL GEOMETRY.

Let not the practical student be repelled from the study of this treatise, as if there were something unintelligible in the word Geometry. A geometrical form is simply a regular form, or a form of which the development is founded on some definite rule—a geometrical rule or law. A piece of lump-sugar, casually broken from a larger mass of the same substance, or a clod of earth turned over by the plough, or the outline of the sea-coast, cannot be said to possess a geometrical form, in the ordinary sense of the phrase; because we followed no law of form in giving a separate existence to the former objects, nor can we recognise any regularity in the form of any one of the three. In each case, the form is rather a compound of a multitude of other forms equally irregular, thrown together in an irregular manner. In a more comprehensive sense, indeed, it may be affirmed, without contradiction, that the form of the clod, such as it is, has resulted from the recognised laws of gravity and cohesion, and must of course possess some definite relation of parts; but without being hypercritical, and raising any argument on this point, which is really beside the question, every intelligent artisan will understand the nature of the distinction, as regards form or outline, between *shapeless* masses of wood, iron, earth, or loaf-sugar, and the erect, square, and rounded mass of a steam cylinder, or the precise exactitude of a spur-wheel.

Again, to approach still nearer, by comparison, to the distinctive idea of geometrical forms, there are many forms which, while they are not geometrical, are nevertheless characterised by a simplicity, harmony, and grace, which set them at a wide distance from such rude forms as those we have been contemplating. We need only allude to the human form, as a pre-eminent example of the distinct class of forms now alluded to. The simplicity of the human form is greatly owing to its being composed solely of curve lines; now, not only are straight lines excluded from the figure, but circular lines also, at least so far as that they never constitute any feature in the outline. In tracing the contour of the body in any given attitude, or from any given point of view, we no sooner arrive at an elevation or a depression which begins to assume a circular outline, than it sweeps into another curve, either rounder or flatter than the one which precedes it, or of which the convergency may be reversed, so as to form an undulation. If we may be permitted to apply the language of geometry at all, we would say that the radius of curvature perpetually varies, and is frequently reversed; and that the utmost approximation to a geometrical analysis of the figure would be the remote generality, that it is composed of very short segments of circles, directly and reversely running into one another. That this definition is of no practical utility, however, is very evident from the fact, that no one ever yet could delineate the human form on geometrical principles, as we daresay no one ever attempted it. He who could seriously set himself to accomplish such an impossibility would be scouted, pitied, or laughed to scorn.

In the meantime, to cut short these preliminary remarks, we hope we have succeeded in assisting the student to understand what geometrical forms *are not*. It behoves us now to explain to him what geometry *is*, and to initiate him into such of the problems of geometry as are necessary for

his aid in the practical delineation of his compositions. In approaching this introductory exposition, we mean to state and illustrate only such propositions as are of directly practical use in the delineation of all ordinary matters of design, to the exclusion of such as may safely be left to remain within the pasteboard walls of Euclid. We utter this apparently irreverent sentence—irreverent towards the memory of the immortal Euclid—with the proviso, that we speak of what is wanted only for the immediate necessities of the draughtsman—of what he cannot do without. We know from experience that many an artisan will consent to devote his attention to the acquisition of a few plain methods of doing a few plain things, when he would be effectually scared from the regular study of a system embracing the development of the principles of geometry. We heartily recommend the study of Euclid's Elements of Geometry to such as are able and willing to bestow upon it the leisure and application necessary for its prosecution, as they will thereby not only acquire a complete conception of the nature of the science, but will also provide themselves with a fund of general ideas on the relations of figure, which will, in many cases, be of very great advantage to them.

Geometry, then, is the science which treats of the properties and relations of *magnitudes;* that is, of things which have length, or length and breadth, or length, breadth, and thickness. The word is derived from two Greek words, signifying *the earth* and *measure*, obviously embodying the idea of measuring the earth. Some more specific explanations, however, are required; and we shall now explain what are the *things* referred to in the definition.

A *solid* is that which extends in three directions; that is, which has length, breadth, and thickness. The application of these distinctive terms to the three dimensions of a body, is simply a matter of convenience. In applying the reasonings of geometry to a solid, it does not matter though the solid were turned upside down, or round about; whether its thickness or height should exchange its name for its length, or its length under one aspect should be called its breadth under another aspect.

A *surface* or *superficies* is that which has only length and breadth. It may be called the boundary of a solid, as it has no thickness.

A *line* has only length, without either breadth or thickness; and it may properly be distinguished as the boundary of a surface, the simple termination of it.

A *point* has neither length, breadth, nor thickness; it has simply position. For example, the intersection or crossing of two lines which pass through each other, is a point; it obviously has a position or locality, but cannot be said to have either length, breadth, or thickness. In like manner, the extremity of a line is a point; it terminates the line.

In attempting to represent lines and points on the surface of paper by means of drawing instruments, the representations can never more than approximate to the things intended to be shown. For the finest line that can be drawn will have *some* breadth; and, indeed, if it had no breadth, it could not be visible. In the same way, a point may be represented by a very minute dot or puncture on the surface; still, as it covers *some* surface, it is not a geometrical point; it is only an approximation, or something very near what is intended. Since, then, all material representations of objects on paper, by means of lines, are really only approximations in proportion to the fineness of the lines employed, those drawings will be the most correct in which the finest lines are employed, other circumstances being the same. It should be understood, then, that the foregoing definitions are not without their practical value, as they set before the student the standard of perfection to which, if not really attainable, he should strive to approach as nearly as possible.

In studying the following definitions, the reader is requested to refer, where necessary, to the accompanying Table of Geometrical Figures for illustrations of the objects of the definitions.

A *straight line* is the shortest way between the points constituting its extremities. Straightness is exemplified in the strings of a violin when screwed up into a state of tension. If a straight line were bent at particular points in its length, it would become a *series* of straight lines, termed in familiar language a *zig-zag*.

A *curve line* is one which continually changes its direction between its extremities. It is evidently not the shortest way between its extremities; neither is it a zig-zag, as this is composed of straight lines.

A *plane surface*, or *plane* simply, is a surface which contains the smallest extent of surface that can be enclosed by its boundaries. This is exemplified in the end of a drum, which, when screwed up or stretched into musical trim, is perfectly *flat*, as we would say in ordinary language. And it is clear that the shortest distance between any two points on the surface of the drum-end, must lie in that surface; that is, in general, if any two points be taken in a plane, the straight line which joins them will lie wholly in that plane. For illustration of this, if we apply a "straight edge" to the stretched surface of the drum, we shall find that it coincides with that surface, into whatever direction it may be turned.

A *curve surface* is one which is continually deflected, no part of it being a plane. The shell of an egg presents a curve surface, whether it be viewed externally or internally. The exterior surface of the superficies is denominated a *convex* surface, and the interior a *concave* surface.

Parallel lines are straight lines in the same plane, which are equally distant from each other at every part. They, consequently, never can meet, though produced or extended ever so far either way.

A *rectilineal angle* is the quantity of divergence of two straight lines, which either meet or cut each other at a point, without regard to the lengths of the lines. As there are numberless positions in which the lines meeting or intersecting may be placed in relation to each other, so there may be numberless angles at which they may stand. These may be arranged into three classes—right angles, obtuse angles, and acute angles.

Fig. 1.

A *right angle* is formed by one line standing on another, so that the adjacent angles may be equal, *each* of these angles being a right angle. Thus the line, D B (fig. 1), standing on the line, A B C, forms with it the two angles at B; and if these angles be equal, then each is a right angle. Further, the line, D B, is called a *perpendicular* to the line, A C, in virtue of its right-angular position.

Here we may shortly explain, that, in designating an angle, we employ the letters used to denote its sides. Thus, the angle contained by the lines, A B and D B, is called the angle, A B D; and that contained by D B and B C is the angle, D B C.

An *obtuse angle* is one which is greater than a right angle. Thus, if the dot line, F I (fig. 2), be at right angles to the line, E F G, the line, F H, inclining to one side of the perpendicular, F I, will form the obtuse angle, E F H.

Fig. 2.

An *acute angle* is one which is less than a right angle. Thus, the line, F H (fig. 2), inclining toward F G, off the perpendicular, forms the acute angle, H F G.

A *plane triangle* is a surface bounded by three straight lines. When three sides are all equal, it is termed *equilateral;* when two of them are equal, it is called *isosceles;* all other plane triangles are classed as *scalene* triangles. Any side may be called the *base.* Triangles are denominated also according to the magnitudes of their angles. When the three angles are acute, a triangle is called *acute-angled;* when one angle is obtuse, it is *obtuse-angled;* when one is a right angle, the triangle is named a *right-angled* triangle.

In a right-angled triangle, the side opposite the right angle is called the *hypothenuse;* the other sides are called, indiscriminately, one of them the *base,* and the other the *perpendicular.*

A *quadrilateral* figure is that which is bounded by four straight lines. When the opposite sides are parallel, it is called a *parallelogram.* When a parallelogram has right angles, it is called a *rectangle;* when a rectangle has all its sides equal, it is termed a *square;* when a parallelogram has no right angles, it is termed a *rhomboid;* when the four sides of a rhomboid are equal, it is termed a *rhombus* or *lozenge.*

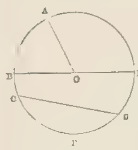
A quadrilateral figure is termed a *trapezium*, when neither pair of its opposite sides are parallel. A trapezium with two sides parallel is called a *trapezoid*.

A *diagonal* is a straight line joining two angles of a figure, not adjacent.

Plane figures of more than four sides are called *polygons*. When the sides of a polygon are equal, it is a *regular* polygon; when they are unequal, it is *irregular*. The distinctive appellations of polygons, derived from the number of their sides, may be learned from the Table, under the head of REGULAR POLYGONS.

The *circle* is a plane figure, bounded by one curve line, called the *circumference*, and is such that the circumference is at all points equally distant from a point within it, called the *centre*. Thus the curve line, A E F, in the annexed figure (fig. 3), is the circumference; the area enclosed is the circle; the point O, from which lines, O A, O B, O E, drawn to the circumference, are all equal, is the centre. Any line, as O A, drawn to the circumference from the centre, is termed a radius; and a line, B O E, passing through the centre, and terminated both ways by the circumference, is called a *diameter*. The radius is, then, half the diameter.

Fig. 3.



An *arc* of a circle is any part of the circumference, as C F D.

A *chord* of a circle is a straight line joining any two points of the circumference, as C D, joining the points C and D.

A *sector* of a circle is the space cut off by two radii, as A O B, or A O E. When the radii are at right angles, the sector is called a *quadrant*.

A *segment* of a circle is the space cut off by a chord, as the space, C F D, cut off by the chord, C D.

A *semicircle* is a portion of a circle cut off by a diameter, as the space, B F E, cut off by the diameter. B E. This space amounts to half the circle.

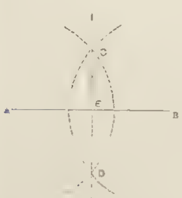
A *tangent* to a circle is a straight line which touches it, meeting it only at one point, called the *point of contact*.

Of *solids* there are a great variety. As planes are bounded by lines, and derive their names from the character and dispositions of these lines; so solids are bounded by surfaces, either plane or curve, and derive their titles therefrom. Regular solids, bounded exclusively by planes, cannot have fewer than four sides. A four-sided solid is termed a *tetrahedron*. A solid having more than four sides is a *polyhedron*. The specific titles of polyhedrons will be learned from the Table, which see also for the definitions of *prism, pyramid,* &c.

If the student has taken the pains to understand the foregoing definitions, he will proceed with pleasure to the study of the following problems and their practical solution.

PROBLEM I. To bisect (or divide into two equal parts) a given straight line by a perpendicular drawn to it.

Fig. 4.



1. To bisect the given line, A B (fig. 4), set one foot of the compasses on the extremity, A, as a centre; and with any convenient radius that is evidently greater than half the line, describe the arc, C D; similarly, from the point, B, as a centre, describe another arc with the same radius, cutting the first one at the points, C and D.

2. Through the points of intersection, C and D, draw a straight line, C E D. This line will divide the given line, A B, into two equal parts, A E, E B, at the point, E; and will also be a perpendicular to the line.

It is not necessary, in practice, to draw the complete arcs, C D. An experienced eye can readily anticipate the points of intersection of the arcs, within small limits. Neither is it necessary to do more than apply a straight edge to these points of intersection, and tick the point, E: unless, indeed, the perpendicular itself be wanted, which is often the case.

The same process serves for the bisection of a circular arc; for, supposing A B to be the chord of the arc, the perpendicular which bisects the chord will also bisect the arc.

Problem II. To draw a perpendicular to a given straight line, from a given point in that line.

First.— When the point is near the middle of the line.

Fig. 5.

1. Let A B (fig. 5) be the line, and C the point near the middle, from which the perpendicular is to be drawn. On C, as a centre, with any convenient radius, set off equal parts, C D and C E, on the line, A B.

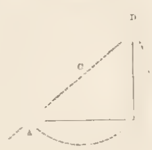
2. On D and E, as centres, and with a longer radius, describe arcs intersecting at F, and, if wanted, on the other side of the line also.

3. Draw the line, F C. It will be a perpendicular to the line, A B, at the given point, C.

Second.—When the point is at or near one extremity of the line.

1. Take any convenient point, C (fig. 6), obviously within the perpendicular to be drawn from the given point, B; place one foot on C, and extending the other to B, describe a circle, A B D, cutting the line A B at A.

Fig. 6.



2. Set a straight edge to the points, A and C, and draw a line, cutting the circle at D.

3. Draw B D, which will be the perpendicular required.

Another Method.—1. From the given point, B, set off, on the given line, a distance such as B A, equal to three of any units of measure, as three inches, or three feet.

2. From B, as a centre, with a radius of four of the same parts, describe an arc, supposed to pass through D.

3. From A, as a centre, with a radius of five parts, describe an arc, cutting the other arc at D.

4. Draw D B for the perpendicular required.

This last method of solving the problem can be easily applied on a large scale for laying down perpendiculars on the ground. Timbers also may be set at right angles by the same method. The numbers three, four, and five, are, it is to be observed, taken to measure respectively the base, the perpendicular, and the hypothenuse, of the right-angled triangle, A B D. Any multiples of these numbers may be used with equal propriety, when convenient; as six, eight, and ten, or nine, twelve, and fifteen, whether inches, feet, or any other unit of length.

When a series of perpendiculars to the same straight line are required, they may, if not above six inches long or so, be drawn with ease by means of a straight edge and a triangle, after one of the perpendiculars has been found, by the foregoing method. Thus, one edge of the triangle, A B (fig. 7), being set to the perpendicular found, and the edge of the rule, C D, applied to the base, if the triangle be slid along the edge of the rule, its side, A B, will run parallel to the line to which it was set, and will consequently yield perpendiculars as far as the rule may extend.

A similar application of the triangle and straight edge enables us to draw parallels to any given line.

Fig. 7.

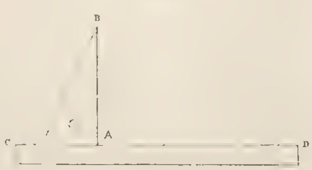
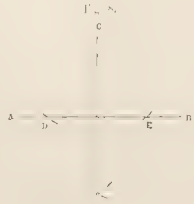


Fig. 8.



Problem III. To draw a perpendicular to a given line from a given point without the line.

First.—When the point is conveniently near the middle of the line.

1. Let A B (fig. 8) be the line, and C the point without it. On C, as a centre, with a conveniently long radius, describe an arc, cutting the line, A B, at the points, D E.

2. On the points, D E, as centres, and with a longer radius (the longer the more accurate the work is likely to be), describe the arcs intersecting at F.

3. Set a straight edge to the points, C and F, and draw a straight line from C to the line, A B. This will be the perpendicular required.

If there be no room below the line, A B, the intersections, F, may be taken above, that is, between the point, C, and the line. This mode is not, however, so good as the one already described, because it is not likely to be so exact.

Second.—When the point is near the end of the line.

1. In the figure annexed to the second case of Prob. II. (fig. 6), let D be the given point, and A B the straight line. From D draw any straight line, D A, meeting A B at A.

2. Bisect A D at C, and on C, as a centre, with C A as a radius, describe an arc, cutting A B at B.

3. Draw D B for the perpendicular required.

PROBLEM IV. To describe a square on a given straight line.

Fig. 9.

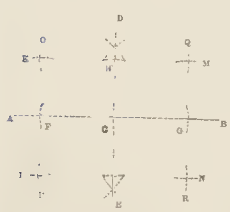
1. Let A B (fig. 9) be the straight line, or the base of the proposed square. Draw A C and B D perpendicular to the base, from its extremities, and make each of them equal to A B.

2. Draw the line, C D; this will complete the square, A B C D, on the line, A B.

A rectangle may be constructed in the same manner. Having determined one of the sides, perpendiculars are drawn from each end of it, of the proper equal lengths, and their extremities joined.

When the centre line of a rectangle is given, the figure may be very accurately described in the following manner:—

Fig. 10.



1. Let A B (fig. 10) be the centre line, and C the middle of the length of the figure. Draw the perpendicular, D E, through the point, C.

2. Set off C F and C G on each side, equal to half the length of the rectangle.

3. Set off C H and C I on the line, D E, each equal to half the breadth of the rectangle; with the same radius, and from the centres, F G, describe arcs, K, L, M, N.

4. From the intersections at H I, and with the half-length as radius, describe arcs, O, P, Q, R, cutting the others. The four lines joining the extreme points of intersection will constitute the rectangle.

PROBLEM V. To draw a line parallel to a given line.

First.—To draw the parallel at a given distance.

1. Let A B (fig. 11) be the given line. Open the legs of the compasses to the required dis-

Fig. 11.

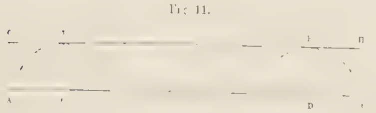
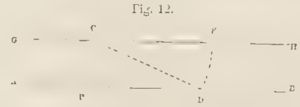


Fig. 12.



tance, and from any two points, C and D, (the farther apart the better,) describe two circular arcs on the side towards which the parallel is to be drawn.

2. Apply a straight edge tangentially to the arcs at E and F, and draw the straight line, G H; this will be a parallel to the given line.

Second.—To draw the parallel through a given point.

1. Let C (fig. 12) be the point; from C draw any oblique line, C D to A B.

2. From C and D, as centres, describe arcs, D E and C F.

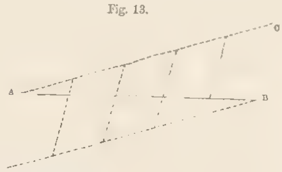
3. Make D E equal to C F, and through the points, C, E, draw the parallel, G H. This is the line required.

The methods of describing squares and rectangles, already given, are also available for drawing parallels, though they are not so generally ready of application as the foregoing.

PROBLEM VI. To divide a straight line into any number of equal parts.

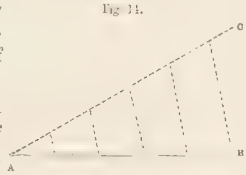
1. Let A B (fig. 13) be the straight line, to be divided into, say, five equal parts. Through the points, A and B, draw two parallels, A C, B D, forming any convenient angle with A B.

Fig. 13.



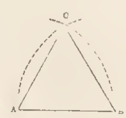
2. Take any convenient distance, and lay it off four times (one less than the number of parts required) along the lines, A C and B D, from the points, A and B respectively; and join the first on A C to the fourth on B D, the second on A C to the third on B D, and so on. The lines so drawn will divide A B into the required number of equal parts.

Fig. 14.



With the assistance of the straight edge and the triangle, or a couple of triangles, this process may be considerably expedited. Thus, having drawn an oblique line, A C, from the point, A, lay off five equal parts on it; set the edge of the triangle to the point, B, and the fifth graduation on A C (fig. 14), slide the triangle parallel to itself in the direction, B A, and draw parallels from the points of division on A C to the line A B; the latter will thus be divided into five equal parts.

Fig. 15.



PROBLEM VII. To construct an equilateral triangle.

1. Let A B (fig. 15) be the length of the side of the triangle. On A and B, as centres, describe arcs, cutting each other at C.

2. Join A C and B C; the triangle, A B C, thus formed, is equilateral.

PROBLEM VIII. To construct a triangle, having its three sides of given lengths.

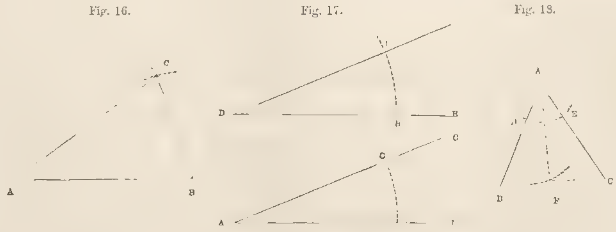
1. Let A B (fig. 16) equal the base of the triangle. On A, as a centre, with a radius equal to one of the sides, describe an arc.

2. On B, as a centre, with a radius equal to the third side, describe an arc, cutting the former at C.

3. Join A C and B C. The triangle is thus completed as required.

This problem is useful in enabling us to locate a point, the distance of which from two other

Fig. 16. Fig. 17. Fig. 18.



points is known. Thus, the position of the point, C, is readily ascertained by the foregoing process, when its distances from the points A and B are given.

PROBLEM IX. To draw a straight line so as to form any required angle with another straight line.

1. Let B A C (fig. 17) be the given angle, and D E the line upon which an equal angle is to be drawn at the point D. From the points A and D, with any convenient radius, describe arcs F G and H I.

2. Set off the length of the arc F G, contained between the lines A B and A C, upon the arc H I; and draw D I. The angle, E D I, will be equal to the given angle, B A C.

PROBLEM X. To bisect a given angle.

1. Let B A C (fig. 18) be the given angle. On A, as a centre, describe an arc, cutting the sides of the angle at D and E.

2. On D and E, as centres, describe arcs, cutting each other at F. The line A F will bisect the angle, as required.

PROBLEM XI.—To find the centre of a circle, or of a segment of a circle.

First. For the centre of a circle.

1. Let A B C D (fig. 19) be a circle, of which the centre is to be found. Draw any chord A C.

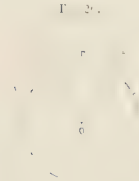
2. Bisect the chord at E, and draw B D perpendicular to it, bounded both ways by the circumference. Then B D is a diameter.

3. Bisect B D at F: this point will be the centre of the circle.

Or the following method may be adopted; and it is the more expeditious of the two.

1. From any point, B, in the circumference, with a radius not greater than that of the circle, describe a circular arc.

Fig. 20.



2. From two other points, A and C (fig. 20), beyond this arc, one on each side, describe other arcs with the same radius, each cutting the first arc in two points.

3. Through the two points of intersection thus found, draw straight lines meeting at the point O. This will be the centre of the circle.

Second. For the centre of a circular segment or arc. The second process for finding the centre of a circle may also be applied to find the centre of a segment. In the diagram annexed to the description of that process, if the segment, A B C, be given, its extremities, A and C, and any intermediate point, B, may be taken for the centres on which the curves are described, and the centre, O, will be found, as already explained. If the curve be greater than a semicircle, as A D C, the same process is applicable; or if it be much greater, the first method may be resorted to. It is obviously of importance that the points, A, B, and C, be well apart, and about equally distant too, and also that the arcs employed be of as large a radius as convenient, as the process is then likely to be more accurate.

PROBLEM XII.—To draw a tangent to a circle through a given point.

There are several varieties of this problem, depending upon the position of the given point, and the accessibility of the centre.

Fig. 21.

First.—When the point is outside the circumference, and the centre given.

1. Let P (fig. 21) be the point, and O the centre of the circle, A. With the radius, P O, on the centre, P, describe the arc, O A B.

2. With the diameter of the given circle, as radius, on the centre, O, cut the arc at B; join O B, and bisect it at C. The line, P C A, will be a tangent to the circle, touching it at A. Here it may be observed, that as the line, P C A, is perpendicular to O B, it is identical with the line employed in the process for bisecting the line, O B; thus there may be but one operation in performing this bisection, and drawing the line, P A.

The tangent may be drawn in the following manner also. Draw B O to the centre; upon P O as a diameter describe a semicircle, cutting the circle in A; the line P A is the tangent.

Second. When the given point is in the circumference, and the centre given.

1. Let A (fig. 22) be the given point. Draw O A D, making A D equal to O A; and draw B A C perpendicular to it, and B A is the tangent required.

Fig. 22.

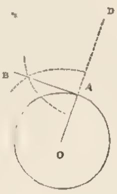
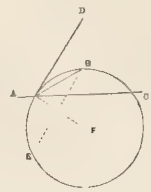


Fig. 23.



Third. When the centre is inaccessible, as the given point is in the circumference.

1. Let A B C (fig. 23) be the given arc, and A the given point. Set off from A two equal arcs, A B, B C, and draw the straight lines, A B and A C.

2. Make the angle B A D equal to the angle B A C. Then A D is the tangent.

This is a very simple operation, and it may be employed with advantage even though the centre be given.

Another mode is to set off on each side of the point A, equal arcs A B and A E; to join E B, and to draw a perpendicular, A F, to it, and finally to draw A B perpendicular to A F.

PROBLEM XIII.—To describe a circle that shall pass through three given points.

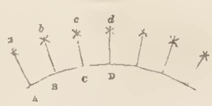
The second process for finding the centre of a circle (Prob. XI.) is exactly applicable for this purpose. Referring to the accompanying figure, suppose A, B, and C, to be the three given points; the point O being found by the method there delineated, it is the centre of the circle required, and by taking the distance to any of the points A, B, C, as a radius, the circle may be described passing through all the three points.

Also this problem is obviously identical with that which requires to circumscribe a triangle, as in this case a circle is to be described passing through the three points terminating its angles; the problem which proposes to describe an arc of a circle passing through the extremities of a straight line with a given *rise*, is but another form of the one now discussed. For example, in the figure accompanying the first process under Problem XI., if A B be the straight line, and E B the given rise, being a perpendicular to it at the middle point E, it is clearly a case of the 12th problem; as we have the three points, A, B, C, and we wish to describe an arc passing through these three points. This problem will be useful for finding the diameter of any large object, when only a part of the circumference is accessible.

PROBLEM XIV. To draw a number of radial lines upon the circumference of a circle, the centre being inaccessible.

1. If the radii are at equal distances, divide the circumference, or a part of it, into the required number of equal parts, at the points A, B, C, &c.

Fig. 24.



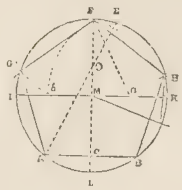
2. On the points A, B, C, &c., as centres, with radii larger than a division, describe arcs cutting each other at *b*, *c*, &c.; thus, from A and C, as centres, describe arcs intersecting at *b*; and from B and D, as centres, describe arcs cutting *a*, *c*; and so on. The lines, A B *b*, C *c*, &c., will be radial lines, as desired.

In presenting the foregoing methods of performing geometrical operations, no account is taken of the use that might be made of the common T square, and the triangles, or of the parallel ruler. These instruments will, however, where applicable, assist considerably on many occasions, in simplifying the solution of the problems, and with an accuracy generally quite sufficient for practical purposes. When, for example, a tangent is to be drawn to a circle through a given point in the circumference, one edge of the triangle might be set to the radius at that point, and the parallel ruler set to the perpendicular edge of the triangle, and then shifted to the circumference, where the tangent could be drawn, or, if the tangent be parallel to an edge of the board, the T square will suffice to draw it.

Problem XV. On a given line to describe a regular pentagon.

Let A B (fig. 25) be the given line, bisect A B at C, and draw C F perpendicular to A B. Set off on this line, a length, C D, equal to A B, the given side of the required pentagon. Draw A D, and produce it indefinitely, make D E equal to half A B. From A, as a centre, with the length A E, as a radius, describe the arc E F, cutting C F in F.

Fig. 25.



2. From A F and B as centres, with A B as a radius, describe arcs cutting each other in A and H.

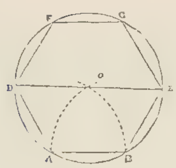
3. Draw the lines A F and H B, when A G F H B will be the pentagon required.

Problem XVI. To describe a pentagon in a given circle. Let A G F H B (fig. 25) be the given circle.

1. Draw the diameters, I K and L F, perpendicular to each other; bisect M K in *a*. Upon *a*, as a centre, with the distance *a* F, describe the arc F *b*. Upon F, as a centre, with the distance F *b*, describe the arc *b* G, cutting the circle at G. Join G A, and carry it round the circle five times, and it will produce the required pentagon. The arcs contained between the extremities of any side of the pentagon, as H K, being bisected as at H K, will give the side of a decagon, or ten-sided figure, inscribed in the same circle.

Problem XVII. To construct a hexagon on a given line.

Fig. 26.



1. Let A B (fig. 26) be the given line. On the extremities of this line, with the extent of the line as a radius, describe arcs intersecting each other at C.

2. On C, as a centre, with the same radius, describe a circle. From the intersections at D and E, with the arcs before described, set off D F and E G on the circle.

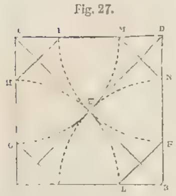
3. Join A D, D F, F G, and E B, which will form the hexagon required.

When the circumscribing circle is given, the following method may be adopted.

Take the radius of the given circle in the compasses, and apply it to the circumference, which will divide it into six equal parts. Draw a chord to each arc, and the six chords will form the hexagon required.

Problem XVIII. To inscribe a regular octagon in a given square.

Fig. 27.



Let A B C D (fig. 27) be the given square. Draw the diagonals, A D and B C, intersecting at E.

Upon A B C D as centres, with a radius E C, describe the arcs, H E L, K E N, M E G, and F E I. Join K G, H I, M N, and F L, and the required octagon is produced.

If a circle is given, in which to inscribe a regular octagon, it may be done in the following simple manner.

1. Draw two diameters at right angles to each other.

2. Bisect the four arcs thus obtained, and draw chords to each; which chords shall form the octagon required.

Problem XIX. To describe any regular polygon upon a given line.

Let A B (fig 28) be the given line. Produce A B any length in either direction, as A C. From A as a centre, with A D as a radius, describe a semicircle, divide it into as many equal parts as the polygon is to have sides; in the present instance we have chosen five, as *a* D *b* *c*, the number of points required to produce a pentagon.

2. Draw lines through all the divisions (minus one), as A D, A *b* E, A C F.

3. From D and B as centres, with A B as a radius, describe arcs, cutting A E in E, and A F in F. Draw the lines D E, E F, and F B; when A D E F B shall be the polygon required.

Fig. 28.

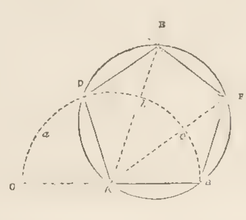
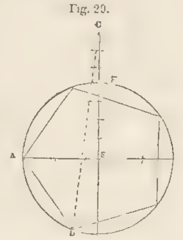


Fig. 29.



Problem XX. To describe any regular polygon in a given circle.

1. Let A F B D (fig. 29) be the given circle. Draw the diameter, A B. From E, as a centre, erect the perpendicular, E F C, cutting the circle at F. Divide E F into four equal parts, and set off three similar divisions from F to C.

2. Divide the diameter, A B, into as many equal parts as the polygon is required to have sides.

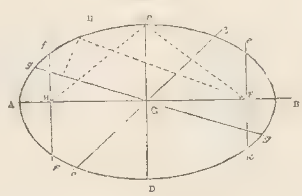
3. From C, through the second division in the diameter, draw the line C D, and A D shall be the side of the polygon required.

In each of these examples we have shown a pentagon, on account of its simplicity, but the same rule is applicable to polygons of any number of sides.

THE ELLIPSE.

The fact of circular surfaces changing their appearance with the different positions of the observer's eye, is so well known as to render any observations on that head needless; but in order to delineate them under all circumstances, it is essentially requisite that the student should understand that the elliptical curve thus assumed by the circular one is strictly regular, and is to be produced by rules as fixed and certain, as that by which we describe the circle itself. With the assistance of the annexed figure (30), which we have selected as a familiar explanation of the principles of the ellipse, the student will have no difficulty in understanding the plain definition of it. The line A B, passing through the length of the figure, is called its *transverse axis*.

Fig. 30.



The point G, which bisects the transverse axis, is the *centre* of the ellipse. The line C D, crossing this centre at right angles to the transverse axis, is termed the *conjugate axis*.

The point F in the transverse axis, and corresponding point H at the same distance from the centre on the other side, are called the *foci* of the ellipse.

A right line *f f* or *e e* passing through a focus of the figure at right angles to the transverse axis, and terminated at either end by a curve, is called the *latus rectum*, or sometimes the *parameter*.

A straight line passing in any direction through the centre of the figure, and terminated at either end by the curve, as *g g* or *h h*, is called a *diameter*.

A line drawn through any diameter parallel to a tangent at the extremity of that diameter terminated by a curve, is called a *double ordinate*.

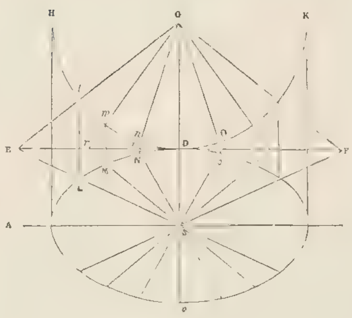
The ellipse is constructed by the motion of a point about the centre of the figure G, beginning its course at the extremity of a diameter, as at A, and taking such a path as that its distance from one of the foci, together with its distance from the other, shall be, in every point through-

out its course, exactly equal to the whole length of the transverse axis, A B. A practical application of this principle is to be found in the following method, which is often resorted to in the workshop for producing an ellipse. In the preceding figure, if the transverse and conjugate axes are given, the *foci* are determined by taking half the tranverse axis, as A G, and with that extent in the compasses, and on the extremity C of the conjugate as a centre, describing an arc, which cuts A B in the points F and H, which are the *foci*.

If pins are fixed in these points, and a thread equal in length to the transverse axis is fastened to them by its extremities, a pencil so applied to the thread as to keep it continually stretched, or forming two straight lines, will, if progressively moved about the centre, describe the ellipse. Thus, in the figure before us, H C F may be supposed to be thread, which, if gradually moved round the centre, will, at different points of its travel, take the position of the inclined lines H and E F, describing by the entire revolution of the pencil the ellipse, A C B D.

PROBLEM XXI. The transverse and conjugate diameters of an ellipse being given, as A B and C D, to describe the curve itself through a number of points, to be determined at the extremities of any number of diameters at pleasure.

Fig. 31.

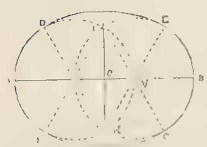


1. Through the extremity, D (fig. 31), of the conjugate axis, draw E F parallel to the transverse axis; extend the line C D to G, and make it equal to A S or S B, half the transverse axis.

2. Upon G, with the radius G D, describe the circle, H D K; through the centre, S, draw the lines, S, L, E, S, M, *r*, &c. at pleasure, respectively cutting the line E F at E *r*, &c. Join the points thus determined on the line E F with the centre G, and mark the points of intersection produced on the arc, H D K, at *l, m, n, o*, &c.; draw lines from H, *l, m*, &c., parallel to G D, until they respectively intersect the extremities of the diameter at A, L, M, N, &c.; these points will be in the periphery of the ellipse, and a curve traced through them will describe the figure.

A figure which is often substituted for the ellipse for practical purposes, but is decidedly inferior to it in point of regularity and beauty of contour, may be drawn by means of circles in the following manner:—

Fig. 32.



1. Let A B (fig. 32) be a given transverse diameter; divide A B into three equal parts, by the points O V. From O and V as centres, with O A or V B as a radius, describe equal circles, D V F and E G O, cutting each other in the points I and K.

2. Draw the lines K O D, I V G, I O F, and K V E, cutting the circles in the points D E F and G.

3. From I and K as centres, with K D or I G as a radius, describe the curvilineal tangents, D E and F G, when the figure, A D, E B, G F, will be the ellipse required.

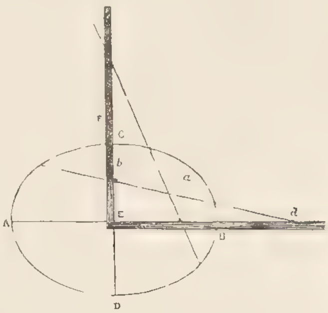
There are various methods of describing ellipses *mechanically* at present in use, probably the best of which is that invented by Mr. Ridley. By this instrument every species of ellipse, from a circle down to a right line, may be correctly formed.

The instrument consists mainly of a beam, *a*, carrying three sliding sockets, *b c d* (fig. 33), which may be set at any distance from each other. On the sockets, *b* and *d*, small sheaves are fitted to revolve on pins, and the centre one, *c*, is fitted to receive a pencil or tracer.

To explain the action of this apparatus, we shall suppose A B to be the transverse, and C D the conjugate axis of the required ellipse, intersecting each other at E. The inner edge of a square, F, is now to be applied to the lines, C, E, B, at such a parallel distance therefrom as to allow the

centres of the sheaves on the sliding bar to move exactly over the centre of the lines constituting the axes of the ellipse. To adjust the position of the sockets to produce the given ellipse, the distance between the pencil and the sheave, *b*, is made equal to half the length of the transverse axis, and *c d* equal to half the conjugate. If now the bar is moved along the edge of the square, as shown by the dotted lines, the tracing point will describe one quarter of the ellipse, each of the remaining portions being described in a similar manner.

Fig. 33.



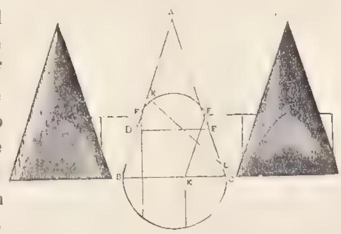
This simple apparatus has since been considerably improved; instead of the plain square of wood, two grooved pieces of metal crossing each other at right angles, so as to form four squares, are substituted. The pins in the pencil beam are fitted to slide in the grooves which are made along the upper side of the squares. In this manner, the whole of the ellipse may be described at once, with the exception of the slight portion which the thickness of the square covers; these are easily filled in by hand.

We now come to the consideration of the two curvilineal figures, the parabola and hyperbola, which, together with the ellipse, are generally treated under the head of Conic Sections, that is, as curves produced by the intersection of a flat surface with the curve surface of a cone.

Let A B C (fig. 34) represent a vertical section through the centre of a cone, the figure which is produced is a triangle.

If the entire cone is cut by a plane passing through it in the direction of D E, parallel to the base, the figure produced will be similar to the base, that is, a circle.

Fig. 34.



If the section is made in the direction F K, parallel with the opposite sloping side of the cone, as A B, the curve described on the surface will be a parabola. If the intersecting plane pass through the cone in the direction F I, perpendicular to the base and parallel to the axis, the curve produced on the surface of the cone by the section is an hyperbola.

If the intersecting plane pass through the cone in any oblique direction, as K L, the curve described on its surface will be an ellipse. As we have already explained the construction of the ellipse, we shall now proceed to examine that of the parabola.

THE PARABOLA.

In order to enter fully upon the geometrical construction of this figure, we shall, in the first place, exhibit its mechanical formation, so as to enable us to set before the student the most explicit rules for application in practice.

In the annexed figure (35), let A B C be a straight-edged ruler, and A B D a common joiner's square; and let a thread of a length equal to B D be fixed by one extremity to the end of the square D, and the other to any point E, between the two rulers. If now the side A B of the square be moved along the edge of the ruler, A B C, and a pencil is applied to the edge B D, so as always to keep the thread stretched, at the same time that it allows it to slip round its point F, the pencil will describe a curve, F L H I, which is a parabola.

The point E, about which the thread moves, is called the *directrix.*

A line H K, drawn through the focus E, and perpendicular to the directrix, is called the *axis* of the figure.

The point H, in which the axis cuts the curve, is called the *vertex* of the figure.

A line G N, passing through the focus E, at right angles to the axis, and terminated by the curve, is the *parameter.*

Any line which can be drawn within the limits of the curve, parallel to the axis, as J K, is called a *diameter.*

If a tangent were drawn to J K at J, the extremity of the diameter, a line L O, drawn parallel to it, is called a *double ordinate.*

That part of any diameter which is contained within any part of the curve itself and its ordinate, as J K, is termed an *abscissa.*

Fig. 35.

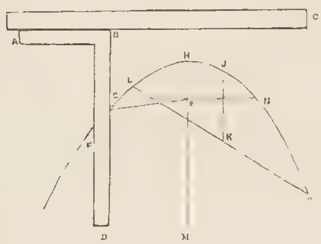
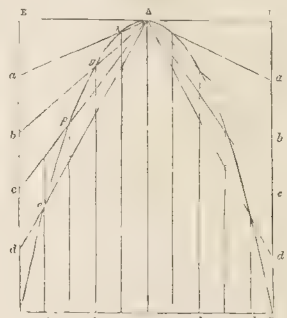


Fig. 36.



PROBLEM XXII. Let A B (fig. 36) be the given axis of a parabola, and C D a double ordinate. It is required to delineate the curve by a process which shall determine a number of points in its course.

1. Through A draw E F, parallel to the double ordinate, C D. Through C and D draw the perpendiculars, C E and E F, parallel to A B.

2. Divide B C and B D into any number of equal parts, as five. Likewise divide C E and D F in a similar manner.

3. Through the points *a b c* and *d* in C D, on each side of the point B, draw the perpendiculars *a e b f c g d h*, &c., and through the points *a b c* and *d,* in C E and D F, draw lines to the upper extremity A, of the transverse axis A B, respectively, cutting the perpendiculars drawn from the line C D, in the points *e f g h,* then will the points of intersection to the right and left of the transverse axis be situated in the curve of the required parabola, and which will be completed by tracing a line steadily through them.

THE HYPERBOLA.

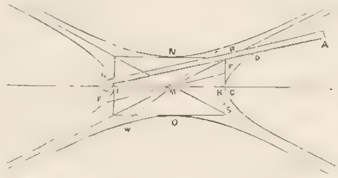
In giving a familiar explanation of the properties of this curve, we shall again have recourse to the mechanical process of its formation, to the end that we may the more easily define its leading characteristics.

Referring to the accompanying woodcut (fig. 37), we shall suppose the points B and C to be determined, and a straight ruler, A B, to be made moveable on one of its extremities, about the point B, as a centre. To the end A of this ruler, one end of a thread is attached, the other being fixed at the determined point C. Now, let a pencil be applied to the thread, so as to press a portion of it against the edge of the ruler, as A D, and keep the other portion, D C, tightly stretched. The ruler being made to traverse on the given point B, at the same time that

the pencil D moves along its edge, always preserving the tension of the threads; and the motion of the pencil or point D, will be in the curve D F G, which is that of an hyperbola.

If the extremity of the ruler, which now moves on the point B as a centre, was removed to C, and there made to traverse in a similar manner, the end of the thread now set at C, being now placed at B, the curve described would be an *opposite hyperbola*.

Fig. 37.



The points B and C, on which the ruler traverses, are called the *foci*.

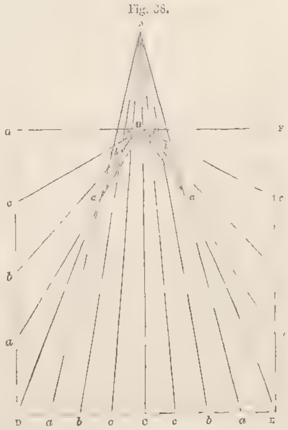
A line terminated by the curves of the hyperbola and its opposite, and which, if continued at either extreme, would pass through either of the foci, as I H in the figure, is called the *transverse axis*. A line passing through the centre M of the figure to the right and left of it, and terminated by the intersection of the arc of a circle, which is described on the point H as a centre, with the distance C M as a radius, is called the *conjugate axis*. Any line, as V W, drawn through the centre M, is called a *diameter*. If a tangent, with either of the curves, be drawn to the extremity of V W, another line, as F F, drawn parallel to that tangent, and through the centre M, is called a *conjugate diameter* to that at the extremity of which the tangent was drawn. A line drawn through any diameter parallel to its conjugate diameter, and terminated by the curve, is called a *double ordinate*. If any diameter be continued within the curve, and is terminated by the curve and a double ordinate, the part within is termed an *abscissa*. A line drawn through the focus of the figure, and at right angles to the transverse axis, is called the *parameter*.

If through the extremity of the transverse axis, I H, a line, R S, is drawn parallel to the conjugate axis, N O, and equal to N O, having H R and H L respectively equal to M N and M O, their right lines drawn through the centre M, and the points R and S, as are the lines M X and M Y, are called *asymptotes*.

When the transverse and conjugate diameters are equal, the hyperbola is termed *equilateral* or *right-angled*.

The recapitulation of these dry and uninteresting terms may appear formidable to the student, but he must bear in mind that a complete knowledge of these is essentially necessary to enable him to comprehend and construct any hyperbolic curves with which he may meet in practice. For curves of a large size, the foregoing mechanical system of construction is very useful and accurate; but, as before adverted to, in order to attain a complete knowledge of the subject, as well as to be able to cope with the different forms which occur, it is necessary to understand correctly their geometrical construction.

Fig. 38.



PROBLEM XXIII. The diameter of an hyperbola, A B (fig. 38), its abscissa, B C, and double ordinate, D E, being given, it is required to delineate the curve by determining a certain number of points which shall be in its course.

1. Through B draw G F parallel to D E, and from the extremities, D and E, of the ordinates, draw D G and E F parallel to the abscissa, B C, cutting G F in the points F and G.

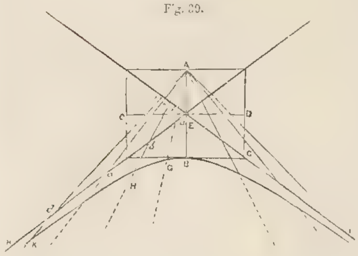
2. Divide C D and C E, each into any number of equal parts, as four; and through the points of division, *a b c*, on each side of the point C, draw lines to A.

3. Divide D G and E F into the same number of equal parts, and from the points of division on D G and E F, draw lines to B. A curve drawn through the intersections at *a b c*, on each side the diameter, will be that of the hyperbola required.

Problem XXIV. The transverse and conjugate diameters, A B and C D (fig. 39), being given, it is required to determine a certain number of points in the curve with a view to its delineation.

Through the extremity B, of the diameter A B, draw F G parallel to C D, the other diameter; and make B F and B G equal to the semi-diameters E C or E D. Through the points F and G thus determined, draw E H and E J, which will be the symptotes of the figure.

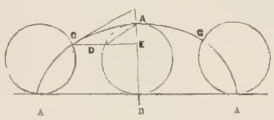
Fig. 39.



From A, as before, draw lines at pleasure towards the curve to be described, as A G, A H, A J, A K, cutting the asymptotes at the points *a b c d*, and *e f g*, and *h*, &c. Set off the distances A *h*, H *g*, A *f*, A *e*, respectively, from the points *a b c* and *d* on the lines from A; and the points G H, J K, will be in the curve required.

If the student has gone over this course of practice in the construction of geometrical curves, by performing the examples themselves on a large scale, he will be enabled, in his future operations, to make use of them in any drawings which come before him in his every-day practice. There are numerous other useful curve lines which admit of regular definitions, as the Cycloid, Epicycloid, &c. The first of these curves, the Cycloid (fig. 40), may be defined in a familiar manner, by supposing it to be the periphery of a cart-wheel rolling along a level road. Thus the circle A B, in the annexed woodcut, may be supposed to represent the cart-wheel rolling in the direction A B A, and A to be the given point in its periphery. Under these conditions, the track of the point A during one revolution will be indicated by the curve line, A C A, G A, which is termed the cycloidal curve. The properties of the cycloid may be briefly defined as follows:—If the generating circle is placed in the centre of the curve, its diameter coinciding with the axis, A B, and if from any point there be drawn a tangent, C E, the ordinate, C D E, perpendicular to the axis, and the chord of the circle, then

Fig. 40.



The right line, C D, = the circular arc, A D.

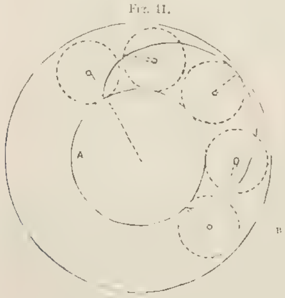
The cycloidal arc, A C, = double the chord, A D.

The semi-cycloid, A C A, = double the diameter, A B, and

The tangent, C F, is parallel to the chord, A D.

If the ball of a pendulum is caused to move in a cycloidal curve, its vibrations will be isochronous; that is, they will all be performed in precisely the same amount of time.

Fig. 41.



The epicycloid (fig. 41) differs from the cycloid in this, that it is generated by a point in one circle rolling upon the circumference of another, instead of a level surface. The cycloid may, however, be brought under the same definition, by regarding the straight line as the circumference of a circle whose diameter is infinitely great.

This definition of the curve will be understood by reference to the accompanying figure, in which A is the *generating* or rolling circle, and B the *fundamental* one, or that upon which it rolls in describing the exterior epicycloidal curve, C D. If the generating circle, instead of rolling on the outside, were to roll within he interior circle, a point in the former would describe an interior epicycloid, or, as it is more recently termed, the hypocycloid.

ORDERS OF ARCHITECTURE.

CHAPTER I.

The moderns have applied the term "order" to those architectural forms with which the ancient Greeks and Romans composed the exteriors of their temples. There are generally understood to be five orders of Architecture, namely—the Tuscan, the Doric, the Ionic, the Corinthian, and the Composite. The Doric, the Ionic, and the Corinthian orders were originally designed by the Greeks, who knew nothing of the Tuscan and the Composite orders. The Romans borrowed the three Grecian orders, and modified them to suit their own purposes; and to these they added the Tuscan and Composite orders. The latter orders, however, have little claim to be separately classed, as they have much in common with the former three. The Tuscan order, by its title, enables us to assign its origin to Tuscany, which is indeed the more certain by the fact, that the Tuscans were originally a colony of Dorians. The Composite order, as the name implies, is compounded from the other orders, and may be called in truth a corrupted Corinthian. The characteristics of an order are determined not so much by the ornaments with which it is embellished, as by the essential proportions of its parts.

It appears then from this, that there are three Grecian and five Roman orders; and the Doric, Ionic, and Corinthian being common to both, they are distinguished as Grecian Doric, Roman Doric, and similarly for the Ionic and Corinthian.

The leading members of an order are—1. a platform; 2. perpendicular supports; and 3. a lintelling or covering connecting the tops of the supports, and covering the edifice. The proportioning of these parts to the edifice and to each other, with the addition of suitable decorations, constitutes an *order* or *rule*. The principal member is the upright support or column, the accompanying members being subservient to this leading feature; the bottom of the column rests either on a general platform, or upon a particular square plinth. The lower part of the column resting upon the square plinth is usually encompassed with a selection of mouldings, which, from their position, are, in conjunction with the plinth, termed the Base of the column. The upper end is likewise covered with a plinth, which, in conjunction with the accompanying mouldings on the upper end of the column, is termed the Capital of the column. The body of the column, or that part situated between the base and the capital, is called the Shaft. The lintelling or covering which lies upon the columns is denominated the Entablature, and is subdivided into three parts—the Architrave, Frieze, and Cornice. The architrave represents a mere lintel, embracing the tops of the columns; the frieze is intended to signify generally the ends of the cross-beams resting upon the lintels, having the spaces between them filled up, and having also a plain moulding to separate it from the a chitrave, and to conceal the horizontal joint formed by the two members; the upper member or cornice represents the projecting eaves of a Greek roof, showing the ends of the rafters. The whole is distinctly exemplified in the Grecian Doric order.

Mouldings.—Before going into the details of the orders, it will be necessary to give an account of the various mouldings employed in Greek and Roman architecture. And, in the first place,

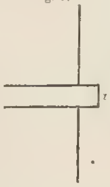
mouldings may be defined to be prismatic or annular solids, formed by plane and curved surfaces, which are employed as ornaments, and are considered as forming constituent parts of an order. If we conceive a straight moulding to be cut through at right angles to its length, the section thus formed is termed its profile, and exhibits exactly its characteristic outline, from which its name is derived. Annular mouldings, again, or such as are formed upon a round surface, as the surface of a column, must be cut by a plane passing through the centre line or axis of the column, in order to exhibit their characteristic sections or profiles.*

A prevailing gracefulness of outline characterises the mouldings of the Grecian orders, which at once distinguishes them from the more unpretending and simpler mouldings of the Romans. Various modes are employed for describing the Roman, and more especially the Greek mouldings, so various are their applications and the modifications of form to which they are subject. The Roman mouldings, however, are usually composed of circular arcs. The Grecian mouldings exhibit every variety of conic section—elliptical, parabolical, and hyperbolical—the circle being seldom employed but in small cavettos and mouldings of contrary flexure.

The regular mouldings are eight in number, and are thus named:—The Fillet or Band, the Torus, the Astragal or Bead, the Ovolo, the Cavetto, the Cyma recta, the Cyma reversa or Talon, and the Scotia.

The *fillet, a,* fig. 1, is the smallest rectangular member in any composition of mouldings. When it stands upon a flat surface, its projection from the surface is generally made equal to its height. In general it is employed to separate other members.

Fig. 1.



In the following descriptions, the extreme points of the curves are always assumed to be given.

The *torus* and *astragal,* shaped like ropes, are intended to bind and strengthen the parts to which they are applied. In form the torus is a semicircle, which projects from a vertical diameter. Thus, in fig. 2, let *a b* be the vertical diameter, from which the torus projects; bisect, or divide in two equal parts, the line, *a b,* at the point, *c*; from *c* as a centre, describe the semicircle, *a d b*; this will be the profile of the torus, which, it will be noticed, is surmounted by a fillet, *b e.* The astragal is described in the same way as the torus, the only distinction between them being that, when employed in the same order, the astragal is smaller than the torus. The torus is generally employed in the bases of columns; the astragal, both in bases and capitals.

Fig. 2.

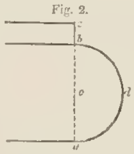


Fig. 3.

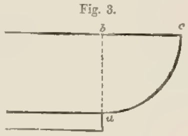
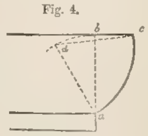


Fig. 4.

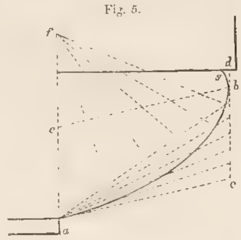


The *ovolo* is a member strong at the extremity, and obviously intended for support; it is usually employed above the eye, as a supporter to the essential members of the composition. The Roman ovolo consists of a quadrant or a less portion of a circle, and is described as in fig. 3, the height and projection being given. And first, let the height be equal to the projection. Draw *a b* equal to the height, and *b c* at right angles with, and equal to, *a b,* for the projection. The quadrant, *a c,* described from the centre, *b,* with a radius, *b a,* or *b c,* is the contour of the ovolo. But, when the projection is less than the height, as in fig. 4, draw *a b* and *b c,* as before, at right angles, *a b* being the height, and *b c* the projection. From the point, *a,* draw an arc of a circle, *b d,* with the radius, *a b,* and from the point, *c,* with the same radius, describe another arc, cutting the former arc at *d*; the point, *a,* is the centre from which the ovolo is to be described, with the radius, *d a,* or *d c*; this being done, the curve, *a c,* is the contour of the ovolo.

* It is by some considered preposterous to lay down rules for the construction of contours, which are said to be subjected to no law of form, except what is furnished by the individual's own taste. Seeing, however, that beautiful outlines may doubtless be traced by means of regular geometrical constructions, we think the insertion of the more common of these methods will be useful to those who cannot readily sketch for themselves.

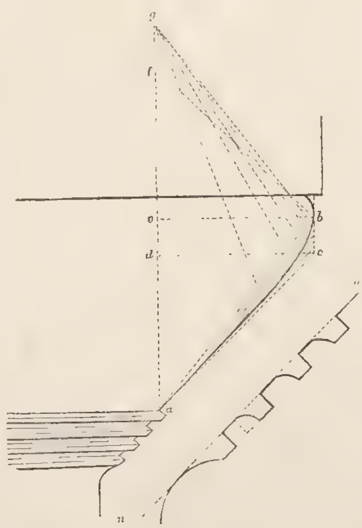
The Greek ovolo, fig. 5, unlike the Roman ovolo, cannot be described by means of circular arcs; it must be described by finding a number of points in it. For this purpose draw the tangent, *a c*, from the lower extremity, *a*, indicating the inclination of the curve at that point; draw also the vertical line, *d b c*, through the extreme point, *b*, or projection of the curve. Draw *b e* parallel to *c a*, and *a c f* parallel to *c b*; make *e f* equal to *a e*; divide the lines *e b* and *b c* into the same convenient number of equal parts; draw straight lines from the point, *a*, to the points of division in *b c*, and similarly draw straight lines from the point, *f*, through the points of division in *b e*, meeting successively the lines drawn from *a* to *b c*; the points of intersection of the pairs of lines thus drawn will be as many points in the contour of the moulding, and a curve line traced so as to embrace these points will be the greater part of the contour. The remaining part, *b g*, if required to be determined in the same manner, may be found by drawing lines from *a* instead of *f*, through the points in *b e*, and from *f* to *b d*, instead of from *a* to *b c*. Of course this will give a good deal more of the curve than is necessary. The curve drawn in this manner is a portion of an ellipse, somewhat greater than a fourth of the whole circumference. The recess of the moulding, *b g d*, at its projecting point, is denominated a *quirck*. Fig. 5 is, from its great projection relatively to its height, adapted for capitals of Doric columns. With less projection, it would be suitable for entablature.

Fig. 5.



To describe the *hyperbolical ovolo*—fig. 6—as employed in Doric capitals; having given the projection, *b*, of the curve, and the lower extremity, *a*, draw the line, *a c*, in the direction of the lower end of the curve, and *b c* vertically through the point, *b*; draw *a g* vertically from *a*, and *b e* and *c d* perpendicular to *a g*; set off *e f* equal to *a d*, and *e g* equal to *a e*; join *b f*, and divide *b f* and *b c* into the same convenient number of equal parts; draw straight lines from *a* to the points of division in *b c*, and also straight lines from *g* through the points in *f b*; the successive intersections of these lines, as in the foregoing case, are the positions of as many points in the contour. This is the general form of the ovolos in the capitals of the Grecian Doric. It will be seen that the lower part towards *a* is nearly straight, and is succeeded by four fillets, shown in section on a large scale, and rounded away on the under sides into the fundamental line, *n o*.

Fig. 6.



The *cavetto*—figs. 7, 8, and 9—which is the reverse of the ovolo, both in regard to form and to the weakness of the extreme parts, is well adapted for purposes of shelter for the other members. It is always employed as a finishing, and is here applied where strength is required. It is never used in bases or capitals, but frequently in entablatures; thus in the Roman Doric order, it forms the crowning member of the cornice, and is evidently employed to overhang and shield the under members. The cavetto is described in the same way as the Roman ovolo; by arcs of circles, which may be either full quadrants or of less extent. The Greek cavetto—fig. 9—is somewhat elliptical, and may be described by a combination of two circular

arcs, thus : Let *a b* be the projection of the moulding, and *a c* the vertical line ; from the point, *a*, draw *b d* vertically from *b*, and make it equal to *b e*, which is two-thirds of *b a* ; from the centre, *d*, describe the arc, *b i* ; draw *i n* perpendicular to *e d*, make *n o* equal to *n i*, draw *o p* perpendicular to *a c*, and meeting *e d* produced in *p*, and from the centre, *p*, thus found, describe the arc, *i o*. The contour, *b i o c*, will represent the Greek cavetto.

The *conge* or *scape*—figs. 10 and 11—is a species of cavetto, and is not recognised as a distinct moulding. In section it is partly concave and partly straight, the latter part being vertical. It is employed in the columns of some of the orders, for joining the capitals and bases to the shafts. Let *a b* be the projection of the moulding from the vertical line, *a e*, which it is required to touch ; and first, if the projection, *a b*, is equal to the height of the curve, make *a c*—fig. 10—equal to *a b* ; and from the points, *b* and *c*, as centres, with *a b* or *a c* as a radius, describe the arcs intersecting at *d* ; from *d*, with the same radius, describe the arc, *b c* ; this completes the contour of the conge. The centre, *d*, may likewise be found by drawing *b d* vertically, and making it equal to *a b*.

Fig. 7

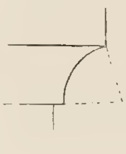


Fig. 8

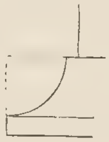
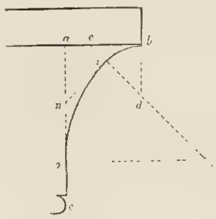


Fig. 9



If the conge contains less than a quarter of a circle, as in fig. 11, let *b e* be the tangent to the curve at the point, *b* ; on the vertical, *a f*, set off the distance, *c d*, equal to *c b* ; draw *b e* at right angles to *b c*, and *d e* at right angles to *c d* ; from the point, *e*, as a centre, describe the arc, *b d* ; this completes the contour of the moulding, *b d f*.

These are the simple Roman forms of the conge. It is obvious that the curve may be varied into a combination of arcs of different radii, in the same way as the cavetto—fig. 9—which would render it more appropriate for Grecian profiles.

Fig. 10

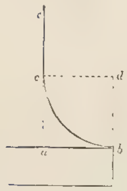
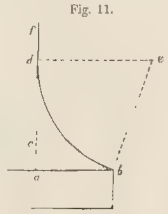


Fig. 11.



The *cymatium*, or *ogee*, is the term applied to a moulding of which the section is compounded of a concave and convex surface. There are two species of cymatium : the cyma recta, or simply, the cyma, and the cyma reversa or talon. The Roman cymatium is usually composed of circular arcs, which may either be equal to or less than a fourth of a circumference. Thus, in the accompanying figures, 12 and 13, the former of which represents the cyma recta, and the latter the talon, let *a* and *b* be the extremities of the curve, join *a b* and bisect, or divide it equally at the point, *c* ; from the points *a* and *c* as centres, with the same radius, describe arcs cutting at the point, *e d* ; likewise, from the points, *b* and *c*, as centres, with the same radius, describe arcs cutting at the point, *e* ; from the points, *d* and *e*, thus found, as centres, describe the arcs, *a c* and *c b* ; then the curve of double flexure, *a c b*, fig. 12, is the cyma recta, and the curve, *a c b*, fig. 13, is the cyma reversa or talon. In the former, it will be observed, the concave portion of the surface is uppermost, whereas in the latter it is undermost. If the curve is required to be made quicker, a shorter radius than *a c* or *c b* must be used in describing the two parts of the contour. The projection of the upper end of the curve over the under, as *n b*, fig. 12, is generally equal to the height, *a n*, of the moulding.

Fig. 12.

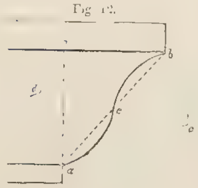
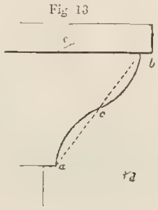
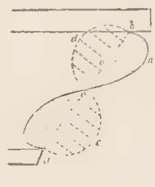


Fig. 13



The Greek cyma-recta differs little from the Roman, except in that its projection over the under fillet is less than that of the latter, and that its curvature is also less. It may be described similarly to the Roman cyma (fig. 12) by means of circular arcs, described with radii of greater length than *a c* or *c b*. The nature of the Greek cyma-reversa, or talon, is represented in fig. 14; the curvature of the moulding is much more deeply marked than that of the Roman talon. The concave portion, *a e*, is deeply indented, and the convex portion, *b n e*, projects considerably, and is *quirked* or turned inwards at *b*. The following is a simple mode of constructing the moulding, first introduced by Mr. A. M. Nicholson:—Join the points, *a b*, the extremities of the curve; bisect *a b* at the point *c*; upon *b c*, as a diameter, describe the semicircle *c d b*, and on *a e* describe the semicircle *a e c*; draw perpendiculars, *d o* and *c*, from any number of points in *b c* and *c a*, meeting the circumferences of the semicircles; from the same points draw a series of horizontal lines, as represented in the figure, equal in length to the corresponding perpendiculars, *o n* equal to *o d*, for example. The curve line, *b n e a*, traced through the extremities of the lines, will be the contour of the moulding.

Fig. 14.

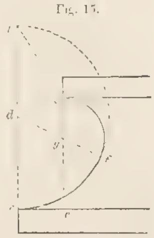


The curve might be rendered flatter by using arcs of circles of a diameter greater than *a c* or *c b*, as, of course, the height, *o d*, of the arcs would not be so great as it is in the figure; this will be exemplified in describing fig. 17, which follows; also, if the upper part, *b n c*, be required to be larger than the under part, *c a*, of the contour, this may be effected by shifting the point, *c*, nearer to *a*, before drawing the circular arcs.

The cyma, like the cavetto, is always used as a finishing, and never applied when strength is required, as it is weak in the extreme parts, though it is applicable as a means of shelter to crowning members. The talon, on the contrary, strong towards its extremity, is, like the ovolo, well adapted for supporting weight.

The *scotia*, fig. 15, like the fillet, is employed in bases to separate, contrast, and increase the effect of other mouldings, and conveys a graceful turn to the profile. To describe the scotia, the extremities, *a* and *b*, of the moulding being given: Draw the perpendicular, *a c*, then *b c* is the projection of the moulding; draw the perpendicular, *b e*; add one-half of *a c* and two-thirds of *b c* into one length, which set off from *b* to *d*; from the centre, *d*, with the radius, *b d*, describe the semicircle, *b f e*; join *e a*, and produce it to *f*; then join *d f*, cutting *a c* in *g*; from *g*, as a centre, describe the arc *a f*; this arc, in conjunction with *b f*, completes the contour, *a f b*, of the scotia.

Fig. 15.



Another mode of describing the scotia is represented in fig. 16. Join the extremities, *a* and *b*, and bisect *a b* in *c*; draw *e c d* horizontally, and make *c d* equal to the required recess of the curve, and *c e* equal to *c d*; draw *f d g* parallel to *a b*; divide *a f* and *a c* into the same convenient number of equal parts, and to the points of division in *a f* draw straight lines from *d*; draw also straight lines from *e*, through the points in *a c*, till they meet successively the lines drawn to *a f*. Having performed the same operation on the upper side, the series of intersections thus found are points in the curve, and by tracing a line through them the contour will be completed.

Fig. 16.

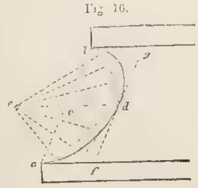
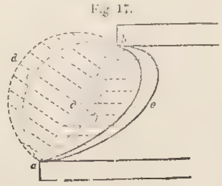


Fig. 17.



In fig. 17, a method is given in some respects similar to the preceding. Having joined *a b*, describe upon it the semicircle, *a d b*; from the centre, *c*, draw a series of lines perpendicularly from *a b*, meeting the circumference, *a d b*; draw also a series of horizontal lines from the same points in *a b*, as shown in the figure, making these lines equal to the corresponding lines in the semicircle, *c e* equal to *c d*, for

I

example; the extremities of these lines will be as many points in the curve. If the recess of the curve is required to be less than *e c*, as, for instance, *c n*, then set off *c o* equal to *c n*, and describe an arc, *a o b*, from the centre, *i*, which will be found after one or two trials; performing the same operation as in the other case, we find the contour, *a n b*.

In comparing these three modes of describing scotias, it is to be remarked that the second is the most generally applicable, whether the recess and the projection be great or small compared with the height. In the third mode, when the projection is small, the form of the curve approximates to that of the circular arc employed in describing it. Both of these modes of description are applicable to mouldings of any recess and projection. The mode first described, to produce graceful contours, should be confined to those of medium proportions, when, for example, the projection is two-fifths of the height, as in fig. 15.

The shaft of a column, like the mouldings which constitute the other portions of the column, may be described with various contours. The shaft is never cylindrical, that is, of equal diameter throughout; it is always tapered to a certain extent towards the upper end. The degree of taper is termed the diminution of the shaft; the diminution usually applied to columns ranges between one-fourth and one-sixth of the diameter at the bottom of the shaft. The following simple modes of diminishing the shaft of a column may be applied, when the diameter at the top and bottom are determined:—

Let the vertical line, A B, Plate A, fig. 1, be the altitude of the column, and B C the half diminution at the upper end of the shaft; divide A B into any number of equal parts, A *a*, *a b*, . . . and also B C into the same number of equal parts, B 1, 1 2, . . . draw the horizontal lines, *a f*, *b g*, . . . and draw other lines from the points 1, 2, . . . slanting towards A, to meet the horizontal lines respectively at the points *f*, *g*, *h*, . . . that is, the line drawn from 1 towards A, to meet the line *a f* at the point *f*, the line from 2, towards A, to meet *b g* at *g*, and so on; the points, *b*, *c*, *d*, *e*, and *f*, thus found, will be points in the contour of the shaft, and by joining them into one bent line, A *f g h i k* C, this line will be the contour, or entasis, as it has been termed, of the column.

But suppose that less swell or bulging is to be given to the shaft; then, in fig. 2, divide A B, as before, into a number of equal parts, and B C into two equal parts at D; divide D C into as many equal parts as A B; then proceed, exactly as in fig. 1, to find the points, *f*, *g*, *h*, *i*, *k*, in the contour. This will obviously bring the outline nearer to a straight line from A to B. In this figure, E F is supposed to be the axis or centre line of the column, E G and E A being the semi-diameters at the bottom, and F N, F C, the semi-diameters or radii at the top. To explain a third mode of determining the entasis of the shaft: On A G as a chord, describe the circular arc, A O G, proportionally less than a semicircle, as the swell is intended to be less; from the point N draw the vertical line, N P, parallel, of course, to E F; divide the arc, G P, into any number of equal parts, G 1, 1 2, 2 3, . . . : divide the altitude, E F, into the same number of equal parts; through the points of division draw the horizontal lines, *f l*, *s m*, *h n*, . . . and draw the vertical parallel lines, 1 *l*, 2 *m*, 3 *n*, . . . meeting the others respectively at the points *l*, *m*, *n*, *o*, *p*; the curve line drawn through these points will be the entasis of the column.

In many instances the shafts of columns are not finished with plain round surfaces; their surfaces are frequently *fluted*, that is, indented by longitudinal flutes or grooves, throughout the whole extent of the shaft. The flutes, when cut, are applied entirely round the shaft, and their profile, which is shown by the section of the column, taken horizontally, is generally an arc of a circle, equal to, or less, than the semi-circumference.

There are two varieties of fluting represented in profile in figs. 3 and 6, Plate A, and shown also in elevation by figs. 4, 5, and 7, 10. In figs. 6 and 7, it will be observed that the flutes are regularly separated by fillets; while in figs. 3 and 4, no such intervention exists, the flutes meet each other edge to edge, and form a sharp angle or arris at their junction; the intervention of the fillets, as they strengthen the projecting angles, permits of the flutes being cut much deeper than when they follow each other consecutively. The circumference of fluted columns are

always measured, in the one case, over the exterior surfaces of the fillets, and, in the other, over the angles formed by the flutes.

To describe the flutes of a column without fillets: Let A B, fig. 3, be the diameter of the shaft at the lower end; bisect A B at G, and describe the semicircle A E F B; draw A D and B C perpendicular to A B, and D C parallel to A B, touching the circle; draw also D E G and C F G to the centre; divide the semi-circumference into half as many equal parts as there are flutes in the whole circumference; more particularly, let there be twenty flutes in the circumference, then ten of these are due to the semicircle, A E F B, and they ought to be so disposed as to have nine of them whole, and the tenth divided between the two extremities, A and B, in order that a flute may stand directly in front, as seen in the figure, where the line, D C, touches the circle. To this end, then, divide the arc, E F, into five equal parts, and continue the division towards A and B, making two whole divisions and a half, as F *d* and *d c*, and *c* B. These points of division determine the arrises of the flutes. To strike the form of the flute, describe arcs from the centres, *c* and *d*, with the radius, *c d*, intersecting at *e*; from *e*, with the same radius, describe the concave surface, *c d*; this forms the flute—the same process is applied to find the others. Having drawn the concentric semicircle, *a b*, for the diameter of the shaft at the upper end, if radial lines be drawn from the arrises of the flutes in the circle, A E F B, towards the centre, G, the points at which they meet the circle, *a b*, will be the arrises of the fluting at the upper end of the shaft, which is described similarly to that at the bottom. The figure, as now completed, becomes a half-plan of the shaft of the column. Fig. 4 is a bottom elevation of the column, derived from the plan, as indicated by the dot lines; and fig. 5 is a top elevation

To describe flutes with fillets in the shaft of a column: Let A B, fig. 6, Plate A, be the diameter of the column; bisect it at G, and describe a semicircle, as before, upon the diameter, A B; draw A D and B C perpendicular, and D C parallel to A B, touching the circle; join D G and C G. Let there be twenty-four flutes in the circumference; there will then be eleven whole and two half-flutes in the semi-circumference, and five wholes and two halves in the quarter circumference. If, therefore, this space be divided into six equal parts, the points of division will be the centres from which the flutes are described, and by running on the divisions to the points A and B, the centres for the whole semi-circumference will be ascertained, and will divide it into twelve equal arcs. Take any one of these arcs, F *d*, and divide it into five equal parts; then, with two of these parts as a radius, from each of the aforesaid centres, describe a semicircle; this will be the section of the flute; the flutes of the interior circle, representing the upper diameter of the shaft, are found by drawing radial lines, which appears sufficiently obvious from the figure. Figs. 7, 8, and 9, are elevations of the bottom of the column, as found from the plan by means of the dot lines; fig. 9 represents the most usual mode of finishing the flutes at the bottom of the shaft; fig. 10 is the corresponding elevation of the upper end.

In describing by relative dimensions the proportions of each particular order of architecture, it is desirable, for the sake of perspicuity and facility of reference, that in all the orders one common standard of measurement should be adopted, to which the proportional dimensions of all the parts of each order should be referred, being expressed in parts of that standard. For this purpose the diameter of the shaft of the column at the base, in each order, is taken as the standard of reference for all the parts or members of the particular order. The advantage of this is twofold; for, first, the proportions of an order are seen by a few glances; and, secondly, the relative proportions of corresponding parts in different orders are likewise readily ascertained. On this principle we shall proceed in defining the orders separately. The diameter at the base, in each order, is divided into 60 equal parts, denominated seconds, and constituting the scale of parts for the particular order; this affords a ready means of accurately noting the proportions, which are expressed in seconds and fractions of seconds, when these occur.

OF THE GRECIAN DORIC ORDER.

This order, illustrated by Plate A, is the most ancient of the orders, and, while employed by the Greeks, was without a base. The surface of the shaft is usually worked into twenty very flat flutes, meeting each other at an edge—this will be explained by the half-plan given in the plate. The edge is sometimes a little rounded; the upper member of the capital is a square abacus or thin plinth, under which there is a large and elegant ovolo of great projection; on the base or lower part of the ovolo there are three fillets, or annulets, which project from the surface of the ovolo, and have, of course, equally recessed spaces betwixt them; the flutings of the column terminate on the under sides of the lowest of these fillets, being finished by a cavetto or a conge. The general outline formed by the junction of the conge with the ovolo, constitutes a cyma-reversa, the effect of which is most graceful.

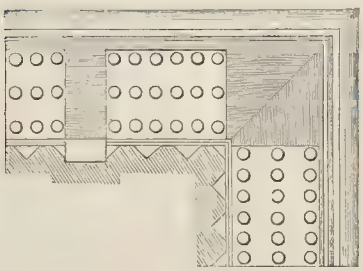
The architrave consists of one vertical face, with a continuous band or fillet at its upper edge; to the under side of this band are suspended a series of smaller fillets, with drops or guttæ; these fillets are of the same length as the breadth of the triglyphs in the frieze, and are placed exactly below them.

The frieze consists of rectangular projections and recesses, placed alternately. The projections or tablets are diversified on the face by two vertical channels, and two half ones cut on the right and left edges, constituting three whole channels, and hence called *triglyphs*. The square spaces alternating with the triglyphs are named *metopes*, and are frequently decorated with sculptures.

The cornice is distinguished by a conspicuous *corona*, a term applied to a vertical or inclined plane surface which considerably overhangs the members underneath. To the corona, immediately over the triglyphs, blocks named *mutules* are suspended, of which the soffit or under side is inclined downwards from the roof; the mutules are also furnished with guttæ or drops depending from their soffits.

The proportions of the different members of the Doric order, as practised by the Greeks, range within considerably wide limits. The following are the average proportions for the members of the order. Taking the diameter at the bottom of the shaft as the standard of measurement, the column is six diameters in height. The diameter at the upper end of the shaft is three-fourths of a diameter; that is, the shaft diminishes one-fourth of the diameter. The height of the capital is half a diameter; that of the ovolo, including the annulets, and that of the abacus, are each one-quarter of the upper diameter, the annulets together being one-fifth of one of the parts. The horizontal dimension of the abacus is six times its height.

The height of the entablature is one-third of that of the column, or two diameters. If it be divided into eight equal parts, these are distributed between the architrave, the frieze, and the cornice, in the proportion of 3, 3, 2: thus, the height of the architrave is equal to that of the frieze, and that of the cornice is two-thirds of either. The inner edge of the triglyph at the angle of the building is in a vertical line with the axis of the column; the breadth of the triglyph is three-fifths of its height, which is also that of the frieze, and the breadth being divided into nine equal parts, two are occupied by each glyph or channel, one by each semiglyph, and one by each of the three interglyphs, or flat surfaces between the glyphs.



All this is shown in the annexed figure, which is a horizontal section of a portion of the entablature, viewed from below, and taken through the frieze. It exhibits the section of the

triglyphs, as well as the arrangement of the mutules in the cornice, with their drops. The metopes are square; the height of the capital of the triglyph is one-seventh of its whole height, and that of the metope one-ninth. The height of the cornice being divided into five equal parts, the lowest is given to the fillet, the mutule, and the drops; the next two to the corona, and the remaining two parts are subdivided and disposed of as shown in the detail figure, Plate A. The projection of the cornice over the capital of the triglyph is equal to its height; and being divided into four equal parts, three are given to the projection of the corona, and they are further subdivided as shown in the plate.

The number of annulets in the capital vary from three to five; and the number of horizontal grooves separating the shaft from the capital, vary from one to three.

In the scales which we have attached to the outline drawing of the order, three sets of dimensions are given, the nature of which are indicated by the initial letters at the bottom of the scales. The first scale contains the "particular heights" of all the members of the order, expressed in seconds, each figure standing opposite the member to which it refers. The second scale contains the "general heights" of the members, each division of the order being specified. The third scale contains the "projections" of all the particular members, beyond the centre line of the column, expressed in seconds.

OF THE GRECIAN IONIC ORDER.

The Ionic order, like the Doric, may be primarily divided into column and entablature; in its secondary divisions, however, a new element is introduced, as, besides the shaft, capital, architrave, frieze, and cornice, it is provided with a base to the column.

The origin of the Ionic order is problematical; its capital, which is its principal characteristic, has been compared to the curls in the head-dress of females, to the spiral horns of rams, the bark of some trees when dried in the sun, the form of various sea-shells, and so on. The order is a medium between the grave solidity of the Doric, and the elegance and delicacy of the Corinthian.

In the architrave and frieze, all appearances of triglyphs and guttæ are omitted; in the cornice, instead of the bold mutules of the Doric, the ends of several pieces of wood are substituted, which are by way of support to the covering tiles, and are represented by dentils or teeth. The other portions of the cornice are analogous to those in the Doric, and consist principally of a cyma, ovolo, and cornice. The great recess of the mouldings under the cornice gives it a striking prominence; this relieves its apparent heaviness, though both the dentil band and the cymatium of the frieze are introduced under it.

The base of the column consists of two tori, separated by a scotia, with fillets, and a square plinth, on which the column rests; though in some cases the plinth is dispensed with, and the column stands immediately upon the general platform which supports the whole.

In the volute of the capital, the lower edge of the channel which runs between the upper and under spirals, is formed into a curve bending downwards in the middle, and revolving about the spirals on both sides. The volute rests upon the ovolo, astragal, and fillet, which terminate the shaft. The ovolo is always cut into eggs, surrounded by borders, with tongues between them. The shaft is, in general, cut into twenty-four flutes, with fillets between them, and the flutes are sometimes made with an elliptical section, which makes them flatter than when they are circular. The taper of the shaft is also less than that of the Doric.

Besides the special dimensions, given in Plate B, of the Ionic order, the following may be noted as the general proportions of the order. The column is eight and a half diameters in height; the diameter of the upper end of the shaft is five-sixths of a diameter; the taper of the shaft is one-sixth. The height of the base, including the plinth, is half a diameter; the heights of the tori and the scotia are nearly equal; the upper fillet of the scotia projects as much as the

upper torus. The projection of the lower torus beyond the lower radius of the shaft, is one-fifth of a diameter. The height of the capital is half a diameter; the height of the volute is seven-twelfths of a diameter; dividing the height of the volute into three equal parts, the top of the lower one reaches to the bottom of the ovolo, and the second division to the top of the festoon, on the axis of the column. The curvature of the outer spiral springs immediately from the ovolo with which the volute is crowned.

Dividing the whole height of the order into twenty-one parts, four of these go to the entablature, which is, therefore, two diameters in height; the height is equally distributed between the architrave, the frieze, and the cornice. Dividing the height of the architrave into four parts, one part is due to the mouldings of the upper portion or capital; subdividing the capital into nine equal parts, give one to the upper fillet, three to the cavetto, four to the ovolo, and one to the bead. Divide the height of the frieze into six equal parts, and give the upper part to the talon, which forms the capital. Divide the cornice into three equal parts; subdivide the upper and lower thirds, each into six parts; in the upper third, give one part to the upper fillet, four to the cyma-recta, and one to the lower fillet, and turn one down into the middle third, for the ovolo under: dispose of the parts in the lower third as appears by the scale.

The projection of the cornice over the cymatium of the frieze is equal to its height; the projections of the subordinate members will be obvious at once from the scales attached.

The volutes of the Ionic capitals are composed of two or more spirals of the same kind, which, after making a number of revolutions, terminate at the centre upon a central point resembling a button, denominated the eye of the volute. The spirals, which project from the surface to give them relief, are termed the *hems* of the volute; the interspaces being called the *channels*.

These definitions will be understood on referring to the detail drawings of the Ionic order, in Plate B. There the front elevation of the capital is represented, showing the central eye, and the spirals terminating in it. The back elevation of the capital is the same as the front. The flanks, shown as side elevations in fig. 1, Plate B, have somewhat the appearance of a balustre. In the plan, fig. 2, this portion of the capital, supposed to be viewed from the under side, appears square in its general outline. Fig. 3 is a vertical section of the capital, exhibiting the profile in flank; fig. 4 is a vertical section, drawn to the same centre line, and in a plane at right angles to that of the preceding section, exhibiting the contour of the front and back elevations of the capital. From these figures it will be observed, that the volutes fit like a cap upon the circular tablet formed by the ovolo. There are no precise rules for the form of the capital in flank, except, perhaps, that the parallel beads which decorate the scroll should run directly into the interspaces of the carvings upon the ovolo; otherwise, the configuration of the parts is left to the taste of the designer. The shaft of the column has been represented fluted in these details, that the correspondence of the flutes with the carvings upon the ovolo may be shown.

To describe the Ionic volute: the number of revolutions or quarters of which the spirals are to consist being given, the vertical height, also, of the spiral, and the diameter of the eye:—Let A B, Plate B, fig. 5, be the height of the volute, and let the spiral make three revolutions, consisting, therefore, of twelve quarters; bisect A B at the point C, and from A B cut off A D, equal to the given radius of the eye; divide D C into as many given parts as there are quarter revolutions in the spiral to be drawn (which in this case are twelve in number), at the points 1, 2, 3, . . . 11, 12. To prevent confusion, we have indicated this division upon a parallel line, D′ C′; draw C E at any angle with C D, and make it equal to two of these parts; join D E, and from the points 1, 2, 3 . . . . draw straight lines, 1 F, 2 G, 3 H, . . . parallel to C E; taking C *d* equal to one part, draw *d f* perpendicular to A B, and equal to 12 E; draw *f g* perpendicular to *d f*, and equal to 11 Q; draw again *g h* perpendicular to *f g*, and equal to 10 P. Proceed in this manner until all the sides of this winding fretwork are drawn; then, the points *d, f, g, . . . p, q, r*, so found, are the centres from which the quadrants which compose the spiral must be successively described. For this purpose, produce *d f* to 1, *f g* to 2, *g h* to 3, and so on; the quadrants, as they are described, will be limited by these lines; from the centre, *d*, with the radius, *d* B, describe the

quadrant, B 1; from the centre, f, with the radius, f, describe the quadrant, 1, 2; from g, with the radius, g 2, describe in like manner the quadrant, 2, 3; proceed in this way till the last arc, 11, 12, is described from the centre, q, with the radius, q 11; then, finally, describe the circle at the centre, from the point, r, and with the radius, r 12. If the operation be accurately performed, this radius, r 12, will be equal to A D, as required, and the spiral line will be completed.

But as the process, as it is now described, is very liable to inaccuracy, the method of finding the centres shown on a larger scale at fig. A, is at once more expeditious and more certain. Having drawn $d f$ perpendicular to the vertical line, bisect it at e; draw $e r$ perpendicular to $d f$, equal to $d e$ or $e f$, and join $d r$ and $f r$; divide $e r$ into three equal parts, $e s$, $s t$, $t r$, and draw $i s k$ and $n t o$ parallel to $d f$; draw $f g$ perpendicular to $d f$, and equal to 11 Q; draw $g h$ and $i h$ respectively parallel and perpendicular to $d f$, meeting at the point h; draw the diagonals $g p$ and $h q$ parallel to $d r$ and $f r$, and draw the perpendiculars $k l$, $o p$, $r q$, $n m$. In this way all the centres are determined, namely, $d, f, g, h, \ldots o, p, q, r$.

To describe the second spiral line, which, with the first one, comprehends the thickness of the hem, a similar process is applicable. Set off B R for the thickness of the hem at that part, and, supposing the hem to diminish in thickness by equal amounts for each half revolution, divide B R into six equal parts; as the spiral describes six half revolutions, it will diminish in thickness one-sixth of B R for each half revolution; set off, therefore, A S equal to 5-6ths of B R, then R S is the height of the second spiral. Bisect R S at T, and set off S V equal to the radius of the eye; then, dividing T V into 12 equal parts, the method already described for finding the centres may be applied.

The method already described, though it is well adapted to the description of the single spiral, is not applicable where there are many spirals. In this case, the principle of the logarithmic spiral may be employed. The nature of this spiral is such, that being divided into equal angular segments, as quadrants or half quadrants, its distances from the centre, at the ends of the segments successively, decrease in a geometrical ratio.

To describe the Ionic volute, on the principle of the logarithmic spiral: the centre, the vertical height, and the distance between the first and second revolutions of the outer spiral being given.

Definition.—The vertical line O A, fig. 6, drawn from the centre O of the spiral, and expressing also the height of it above the centre, is termed the *cathetus.*

If then O A be the cathetus, O the centre, and A I the distance between the first and second revolutions, produce A O to E, and draw G O C at right angles to A E; bisect the angles at the centre by the straight lines B O F and D O H; find a mean geometrical proportional between O A and O I, and make O E equal to it; find also a mean proportional between O A and O E, and make O C equal to this mean. Having thus found the consecutive points A, B, and C, the distances of which from the centre are in geometrical progression, the others in succession will be found by the aid of proportional compasses. Having set the compasses, so that the ratio of the lengths of the legs on the opposite sides of the centre pin may be that of O A to O B, it is obvious that if the distance A O, be taken between the longer ends, the shorter ends will measure the distance B O; and, in like manner, that if the longer ends be set to B O, the shorter ends will measure C O. Farther, by taking C O in the one end, we have D O in the other; and proceeding in this way, we may find successively the distances E O, F O, G O, &c., which furnish as many points in the spiral; and, by tracing a curve line through the points thus found, the spiral will be completed. The divisions marked off upon the line A G indicate the commencements of the other spirals, of which the volute consists, which, it will be observed, are disposed in three sets.

Another method of setting off the spiral by means of proportional compasses, without pricking the paper, is to construct a scale of parts A B O, fig. 7. This method also expedites the process considerably. Having found O A and O B, as before, and set the compasses in the manner already described, make O A, fig. 7, equal to O A, fig. 6, by the longer ends of the compasses, and mark off O b, the distance between the shorter ends. Take again O b, between the longer ends,

and mark O c, between the short ends; similarly, from O c find O d, and so on, till the distance O i, is found. And here the accuracy of the process may be tested, as O i, fig. 7, should be equal to O I, fig. 6. Join the points of division in A i to the point B; draw the horizontal line i E, and from E draw the vertical E F, cutting i B at the point G; draw again the horizontal and vertical lines G H and H K I. Then the three scales A O, E F and H I, will afford eight points in each of the three revolutions of the first spiral A C E G I: O b is equal to O B, O c equal to O C, O d equal to O D, and so on; and lastly, O i or F E is equal to O I. Following the same process, the eight divisions on the scale F E give eight points in the second revolution I K L, and the scale I H gives eight points to the third revolution L M N.

The points thus determined for the spiral may be transferred to the edge of a slip of paper, and thence marked by a pencil point upon the drawing, fig. 6.

The same scale, fig. 7, may be employed for the other spiral lines in the volute, the commencements of which are marked on the line A I, fig. 6, for, by dividing the parallel line A i, which is equal to A I, in the same manner as A I, and drawing horizontal lines from these several points of division, as indicated in the figure by dot lines, the perpendiculars drawn from the points at which these lines meet A B, furnish scales for the first revolutions respectively. For example, if we draw a horizontal line L M from the point L, meeting A B at the point M, the perpendicular M O N becomes a scale of parts for setting off the first revolution of the spiral which starts at the same point L, fig. 6. The scales P R Q and S U T, formed in the same manner as before, serve to define the second and third revolutions of the same spiral. In this way, then, it is clear we can readily construct a set of scales for each individual spiral. Another mode of finding a series of points in a spiral is represented by the scale, fig. 8.

Referring for convenience to fig. 6, divide the whole height A E into 16 equal parts, making the portion A O above the centre equal to 9 parts, and leaving of course 7 for the portion O E. In fig. 8, make O E equal to O E, fig. 6, and draw a perpendicular O A equal to O A, fig. 6; join A E, and on E as a centre describe the arc A P; divide that arc into 28 equal parts, and join the points of division to the centre E. The straight line A O intersected by these radii at the points, b, c, d, &c., forms the scale for the first spiral: thus O A is the distance O A, fig. 6; O b gives the distance O B, O c gives the distance O C; O d gives the distance O D, and so on; till lastly O n gives the radius O N of the eye, which is described by a circle on the centre O. Having thus marked off a series of points in the curve, it may be completed either by describing arcs of circles connecting the points which have been set off, or by tracing by hand a curve line through them. The other spiral lines of the volute may be described in like manner by making a new scale for each.

In this example, the radius of the eye has been made equal to the first four divisions of the line A, the remaining 24 divisions being distributed along the spiral. We may, of course, secure any number of divisions for the radius of the eye; if we are to secure 8 divisions, for example, then as 24 are due to the spiral, the arc must be divided into 24 + 8 or 32 parts.

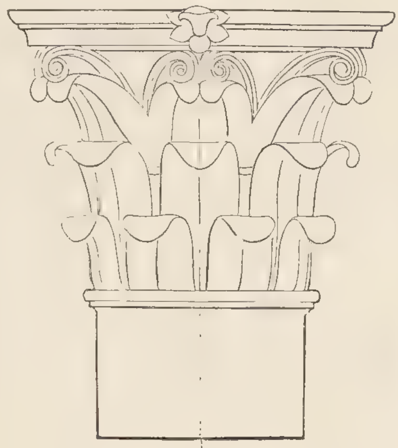
OF THE GRECIAN CORINTHIAN ORDER.

The Corinthian is the third and last of the Grecian orders. Upon this order the ancients lavished the utmost efforts of their creative genius; it is the most magnificent and elegant of the orders.

The great distinguishing feature of this order is its capital. The capital consists of a solid body or nucleus in the shape of a bell, and hence commonly called the bell of the capital; the bell is surrounded with two tiers of foliage, consisting of acanthus leaves, of which there are 8 in each tier; the upper end of the shaft finishes with an astragal, which appears to bind together the leaves at the roots; surmounting these are 8 caulicoli, or twisted and fluted stalks, springing

from between the leaves of the upper tier, and spreading each into two open volutes, which support the abacus: the abacus consists of a square tablet, concave on the four sides or edges, and having the acute angles thus formed cut away; the edge of the abacus is wrought into an ovolo and a cavetto, separated by a fillet—one of the upper tier of leaves fronts each side of the abacus; the space beneath the abacus, unoccupied by the leaves, is taken up with slender caulicoli or stalks, which spring from between every two leaves, and proceed to the corners, and to the centres of the sides of the abacus, where they are formed into delicate volutes. The centre of each side of the abacus is adorned with a rosette, or small flower.

Fig. 1.



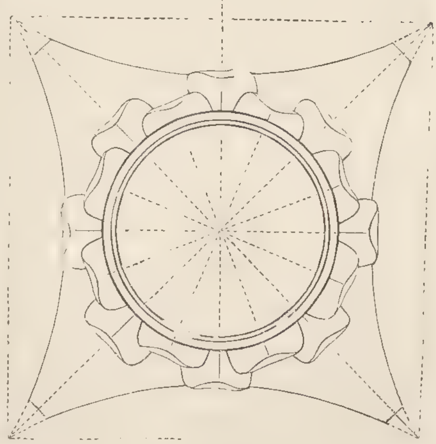


Fig. 2.

The base of the column, as represented in Plate E, is the same as the Ionic base, consisting of two tori, separated by a scotia, the whole resting on a square plinth. The shaft of the column should be fluted when the entablature is enriched.

In the cornice of the entablature the dentil band is preserved, as in the Ionic order, and is overhung by a fascia, from which enriched medallions project. The entablature bears a close resemblance to that of the Ionic order.

The following are the general proportions of the Corinthian order:—In its general arrangement, it is similar to the Ionic: the column is ten diameters in height; the diameter at the upper end is five-sixths of that at the under end, the taper being therefore one-sixth. The height of the base is half a diameter; the projection of its upper torus is equal to that of the upper fillet of the scotia. The height of the capital is $1\frac{1}{6}$ diameters, of which one diameter is occupied by the leaves and volutes, the remaining sixth being given to the depth of the abacus; the height occupied by the leaves and volutes being divided into three equal parts, the lower part is due to the lower tier of leaves, the second part to the second tier, and the third part to the caulicoli and volutes. The height of the principal volutes is three-fourths of one of these parts. The droop or descent of the tips of the leaves is one-third of the height assigned to them; their form is seen more explicitly in the engravings, which give the general form of the foliage before it is cut, in which fig. 1 is the elevation, and fig. 2 the semi-plan of the capital. It will be seen that the circumference of the bell is divided between eight leaves in each tier. The abacus, which is seen in both these figures,

is supposed to be cut from a square plinth, shown in dot lines in the plan, the diagonals of which measure two diameters of the column; the curvature of each side is an arc of a circle. of which the centre is formed by constructing an equilateral triangle upon the side of the square, the vertex of the triangle being the centre. Figs. 3 and 4 show the general form and manner of raffling the leaves.

Fig. 3.

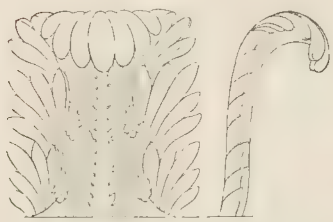
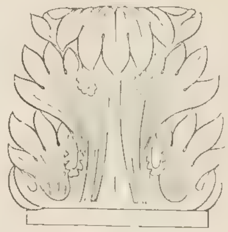
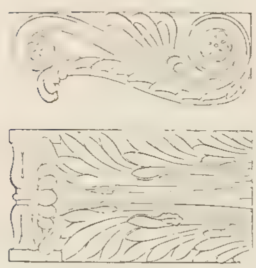


Fig. 4.



Dividing the whole height of the order into five parts, one of these is due to the entablature, which is therefore one-fourth of the height of the column, or two and a half diameters high. The architrave is three-fourths of a diameter high, the frieze is two-thirds, and the cornice one and a twelfth. Dividing the height of the architrave into five parts, one of these is due to the fillet, the quirked cyma-reversa, and the bead; the other four parts are divided equally among the three fascia which compose the remainder of the architrave. The frieze is commonly ornamented, though frequently left quite flat and plain. The height of the cornice being divided into three parts, they are disposed among the members in the manner exhibited by Plate C. The projection of the cornice over the frieze is equal to its height; the projections of the members of which it is composed are given on the plate. The modillions which overhang the dentil band are represented in fig. 5.

Fig. 5.



OF THE ROMAN DORIC ORDER.

In the progress of their conquests, the Romans extended their dominions over the colonies of Greece, over Greece itself, and over some parts of Asia. It was not till they had acquired the mastery of these, their more polished neighbours, that they possessed any opportunity of becoming acquainted with the architecture of Greece, as well as with its sculptures and paintings. The columnar architecture of the Romans, imitating that of the Grecians, is evidently of the same family, though greatly inferior in simplicity and harmony. The Doric order of the Romans, which we are now to describe, affords an illustration of this remark; it strikingly contrasts with the simple and energetic Doric of the Grecians, and is by no means an improvement on this beautiful order of architecture.

The column of the Roman Doric had originally no base, but the addition of a base is certainly an improvement, and renders the parts of the order consistent with one another. The capital has a greater number of members than that of the Grecian, and are of a light and round character, while those of the other are broad and flat. The shaft is more slender than the other, and is very seldom fluted; when it is fluted, the flutes are separated by fillets, as in fig. 6, Plate A, and are twenty in number; the shaft is finished at the upper end with an astragal and a fillet, which support the capital, instead of one or more channels, as in the Grecian. In the capital, three fillets, with a quarter-round and a semi-torus, are intended to represent the ovolo and

annulets of the Greek capital; and the height of the abacus, instead of being plain, is divided into a projecting fillet, a cyma, and a fascia.

The architrave is, like the other, furnished with a band along its upper edge, from which the fillets and guttæ depend. The guttæ, also, are six in number, but are coniform instead of cylindrical, and project from the surface of the architrave fully more than half their diameter. The face of the architrave is vertical, and stands in a line with the superior diameter of the column, though it is sometimes set a trifle within the point. In the frieze, the triglyphs project from, instead of being coincident with, the architrave; and those next the angle of the building are, as represented in Plate C, placed directly over the centre of the column, instead of being on the angle; the glyphs, of which there are two wholes and two halves, are finished square at the upper edge, and the tops slope downwards towards the back at the same angle with the sides.

In the cornice, the members are all lighter than those of the Grecian (there is, in fact, a greater subdivision), with the exception of the mutules, which are boldly developed, and have no guttæ.

Besides the special dimensions which we have given in Plate C, we may state the following general proportions of the order:—Dividing the whole height of the order into five equal parts, one of these is given to the entablature, the height of which is therefore one-fourth of that of the column. The column tapers one-sixth throughout the shaft, and is eight diameters high, of which one diameter is distributed equally between the capital and the base. The plinth in the base is one-third of the height. The height of the capital is nearly equally divided between the abacus with its mouldings, the ovolo with its fillets, and the neck.

The entablature is two diameters in height, and being divided into eight equal parts, these are distributed among the cornice, the frieze, and the architrave, in the proportions of 3, 3, and 2. This distribution contrasts strongly with that of the entablature of the Doric. The height of the architrave, which is half a diameter, being divided into three, one of the parts is due to the band, fillet, and guttæ, of which the height of the band is equal to that of the fillet and guttæ together. The frieze is three-fourths of a diameter in height: it is divided horizontally into triglyphs and metopes, of which the former are each half a diameter in breadth, and on the whole depth of the frieze—dividing the breadth of the triglyph into twelve parts, the extreme twelfths are due to the semiglyphs, and the remaining ten parts are distributed equally between the two whole glyphs and the three vertical plane surfaces, or *shanks*, which separate them, two parts being given to each member. The plat-band or fascia, which crowns the triglyph, is one-eighteenth of its height. The cornice is three-fourths of a diameter high. The breadth of the dentils is the same as that of the triglyphs, and their projection is equal to their breadth.

THE ROMAN IONIC ORDER.

The Roman Ionic is the modification of the original Grecian, practised by the Romans after their conquest over the Greeks. The general proportions of the Roman and Grecian Ionics are nearly alike; the minutiæ and detail, however, are considerably different. This will be perceived at once on referring to the plates of these orders—Plates B and D.

In the column of the Roman Ionic, the attic base is always employed. The capital is considerably distinguished from that of the Grecian by the straightness of the under edge of the channel of the volutes over the quarter round, and the absence of the hem which bordered the under side of this channel in the Grecian. The shaft may be either plain or fluted, with twenty or twenty-four flutes, in plan a trifle more than semicircular. The fillets between the flutes should have between one-third and one-fourth of their width. The egg and dart ornament of the quarter round in the capital should correspond with the flutes of the column, there being an

egg exactly over each flute, and a dart, of course, over each fillet. The volutes may be described according to the methods already given for those of the Grecian order.

Dividing the whole height of the order into five parts, one of these pertains to the entablature, the others to the column: the height of the entablature is, therefore, one-fourth of that of the column. The shaft of the column tapers one-sixth; the whole height of the column is nine diameters, half a diameter is given to the base, and seven-twentieths, or twenty-one minutes, to the capital.

The entablature is two and a quarter diameters high. Dividing its height into five equal parts of twenty-seven minutes, two of these parts go to the depth of the cornice, and the remaining three are divided equally between the architrave and the frieze. The faces of the frieze, and the lowest member of the architrave, are directly on the outline of the upper end of the shaft; this gives them a less heavy aspect than the corresponding members of the Grecian, which project considerably. The projection of the cornice from the face of the frieze is equal to its height.

The Ionic entablature is occasionally reduced to two-ninths of the height of the column; this may readily be accomplished without altering its internal proportions, by making its module or scale of parts less, by one-ninth, than the diameter of the column, and setting off its parts from this scale in the proportions exhibited in the plate. In the decoration of the interior of apartments, when much delicacy is required, the height of the entablature may, according to Nicholson, be reduced to even one-fifth of the column, by observing the same method, and making the module only four-fifths of the diameter.

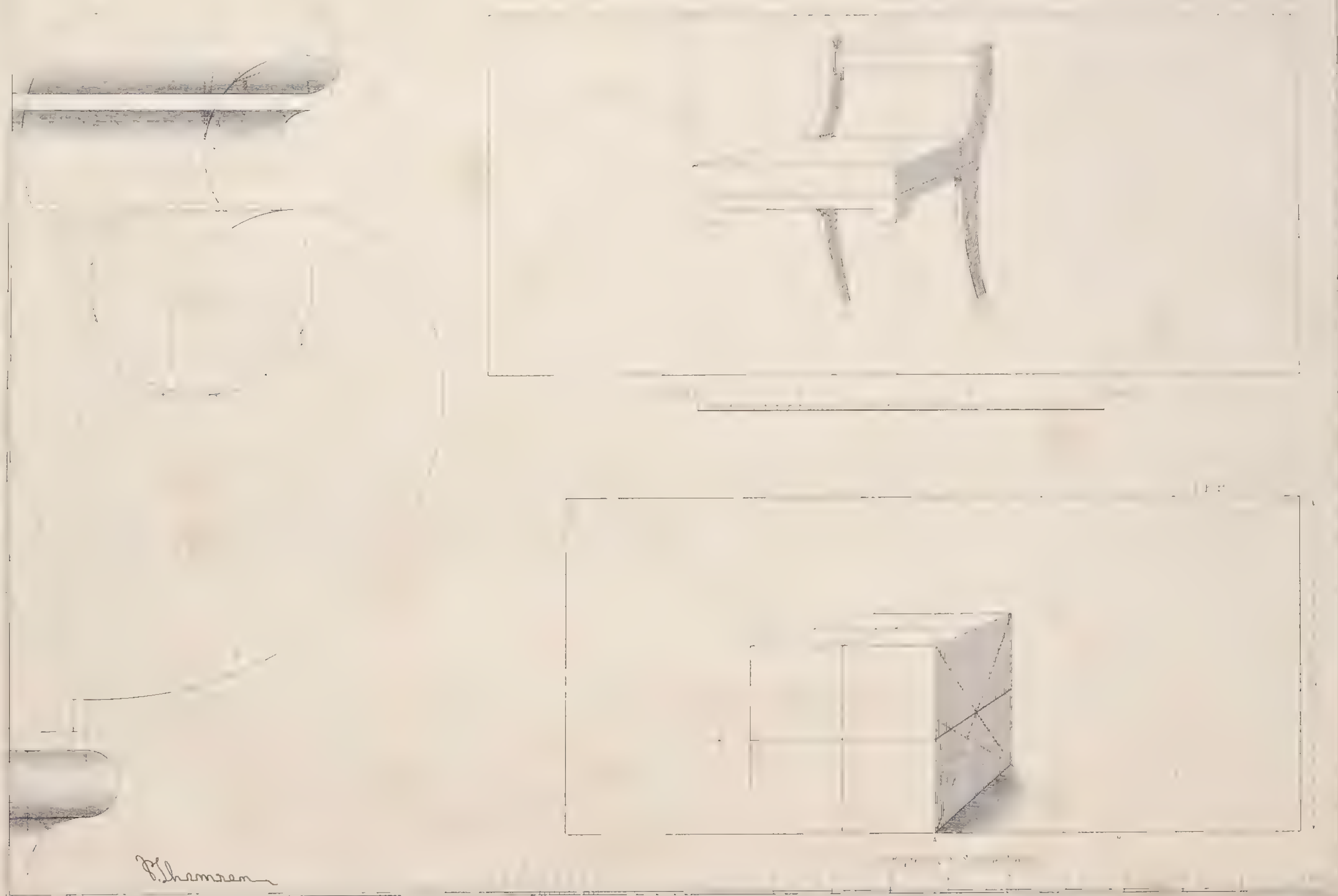
OF THE ROMAN CORINTHIAN ORDER.

This order, Plate D, is the only one in which the Romans have truthfully represented the original from which it is derived. In detail, this order is but slightly different from its prototype.

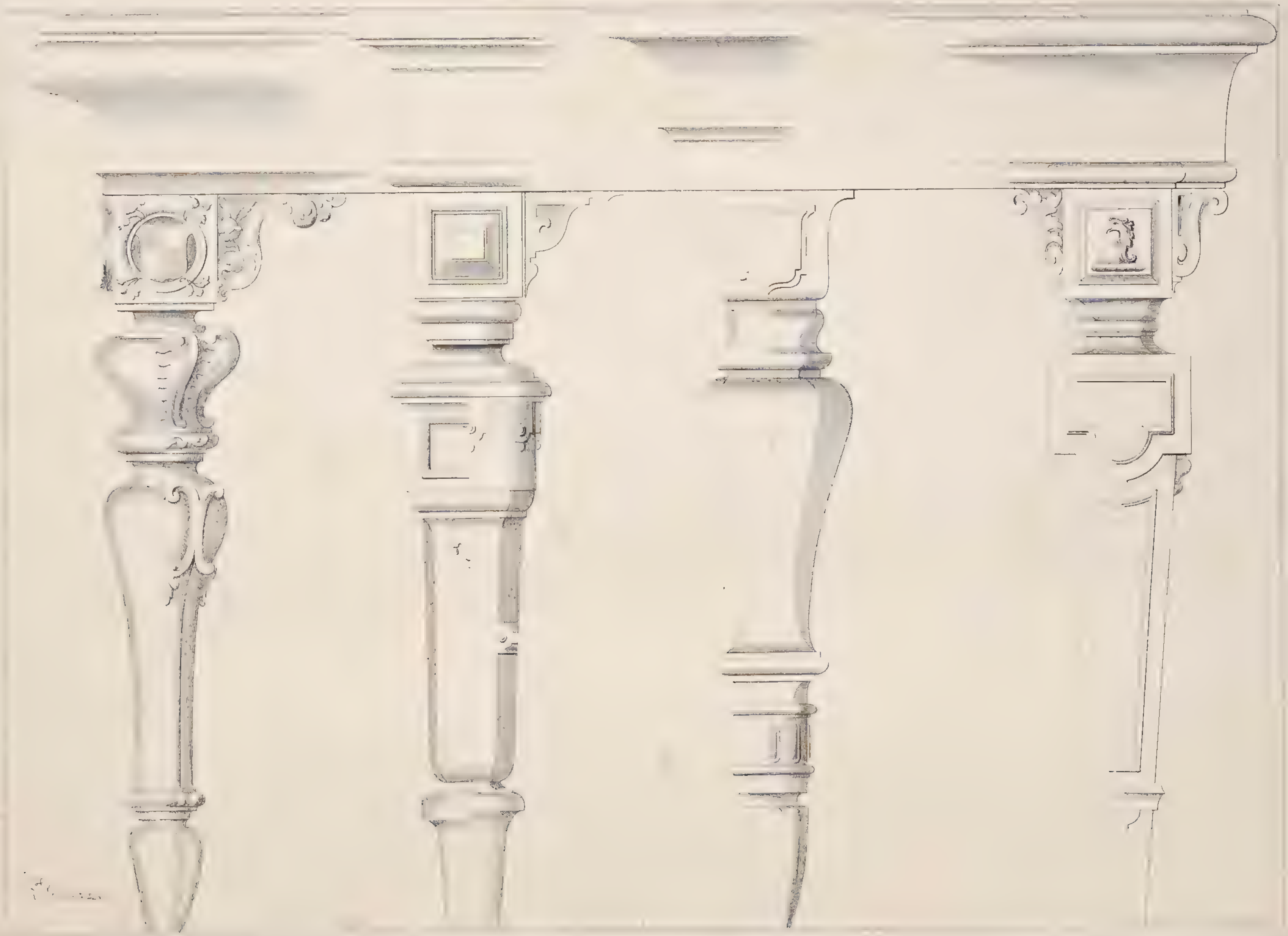
Dividing the whole height of the order into five parts, one part is due to the entablature, which is therefore one-fourth of the column, as in the Grecian. The height of the column is ten diameters, and the entablature, consequently, two and a half diameters. The cornice is one diameter, or two-fifths of the entablature, high; the remaining three-fifths are divided equally between the frieze and the architrave, three-fourths of a diameter to each. These general proportions, it will be observed, are the same as those of the Roman Ionic order. The entablature of the latter is frequently substituted in the Corinthian order.

THE COMPOSITE ORDER.

The Composite order is derived from the three original orders, or, more strictly perhaps, from the Roman Ionic and Corinthian, being a compound of the two orders. There are a great variety of designs recognised as the Composite order; we have given the design in Plate D from Chambers, who, in composing it, endeavoured to avoid the faults and unite the perfections of those with which he was acquainted. The entablature has one-fourth of the height of the column; the column is ten diameters high, consequently the entablature is two and a half diameters, of which the cornice has one diameter, and the frieze and the architrave each three-fourths of a diameter. The base is precisely the same as in the other orders: the shaft is fluted similarly to the Ionic; the capital retains the two tiers of acanthus leaves in the Corinthian, and also the abacus in the same order; the Ionic scroll, however, is introduced between these members. The cornice differs from the Corinthian only in having the medallion square, and composed of two fascias.

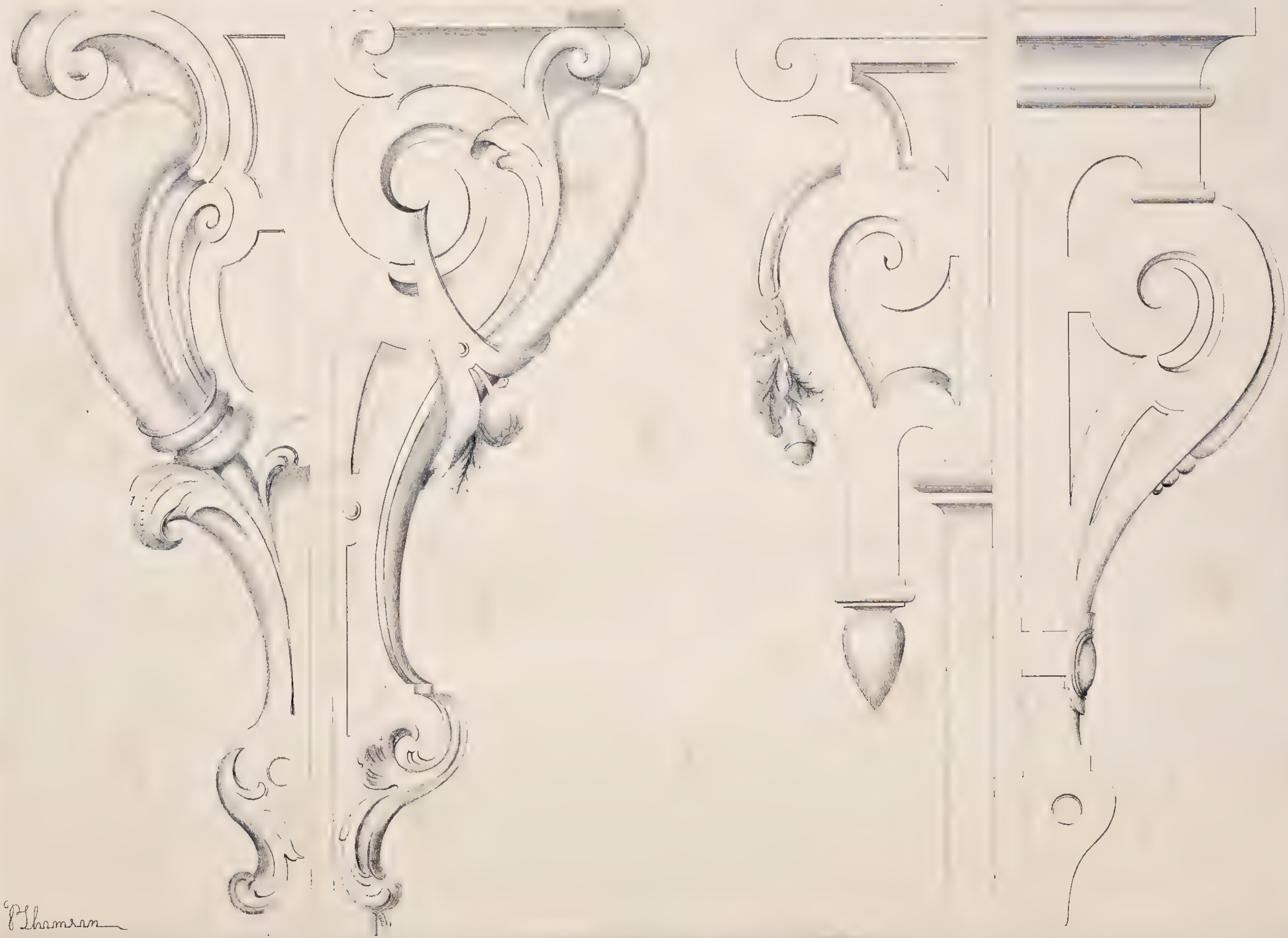


DETAILS FOR HALL TABLES



WARDROBE DETAILS

WARDROBE DETAILS, FULL SIZE

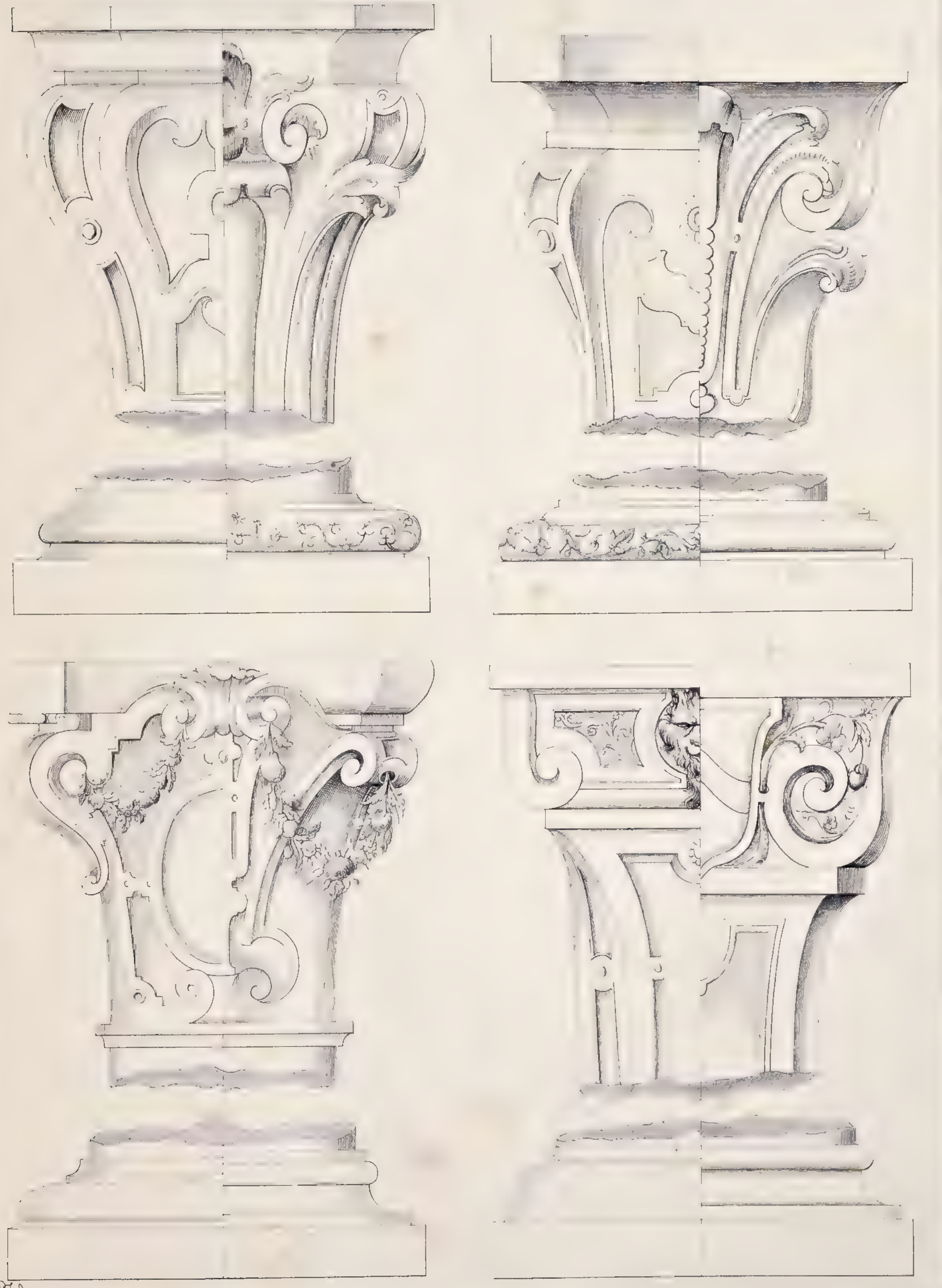


P. Thomson

RAILINGS

WILLIAM MACKENZIE, GLASGOW & EDINBURGH

CAPITALS

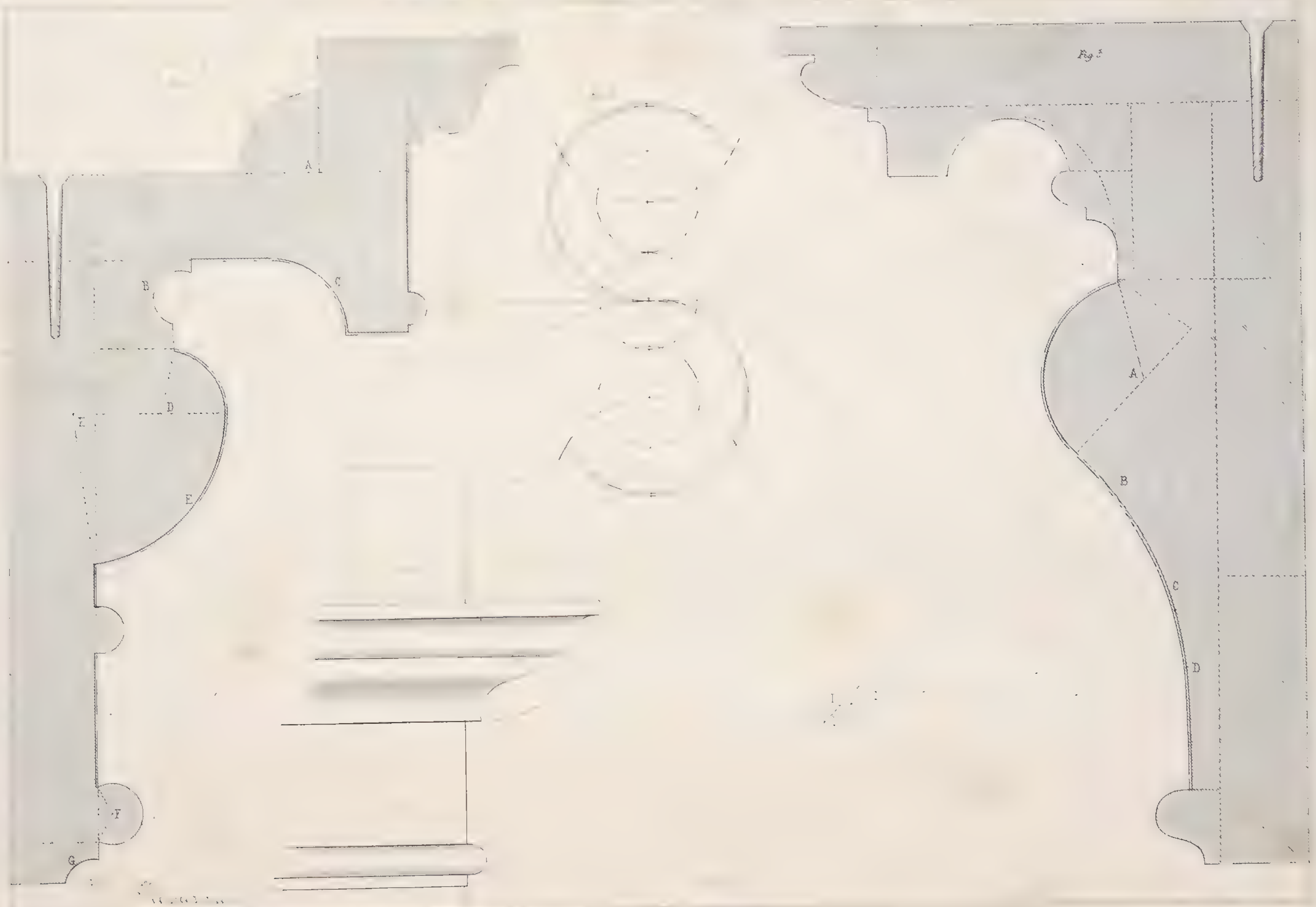


P. Thomson

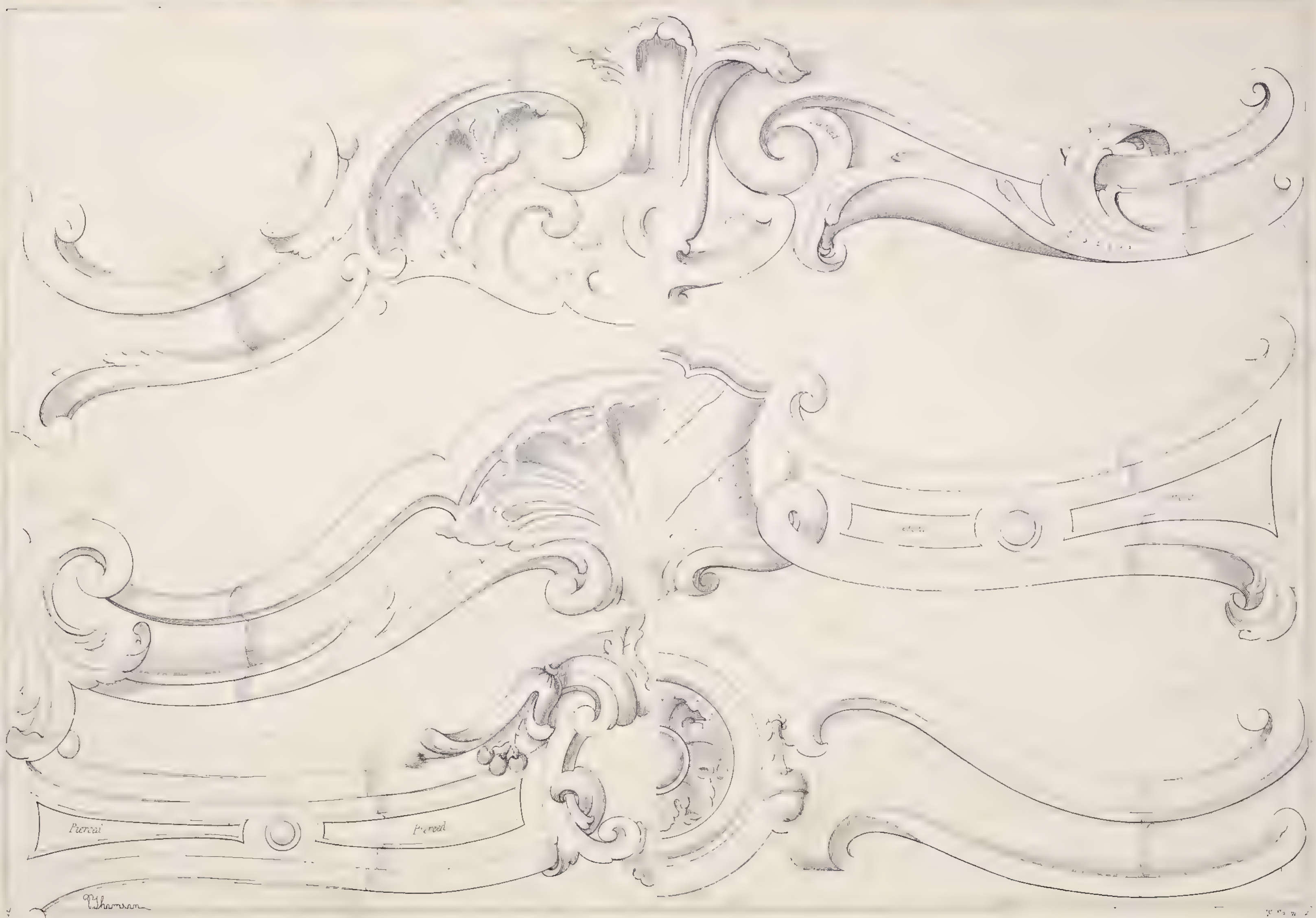
W. Warwick

WILLIAM MACKENZIE, GLASGOW & EDINBURGH

CORNICES

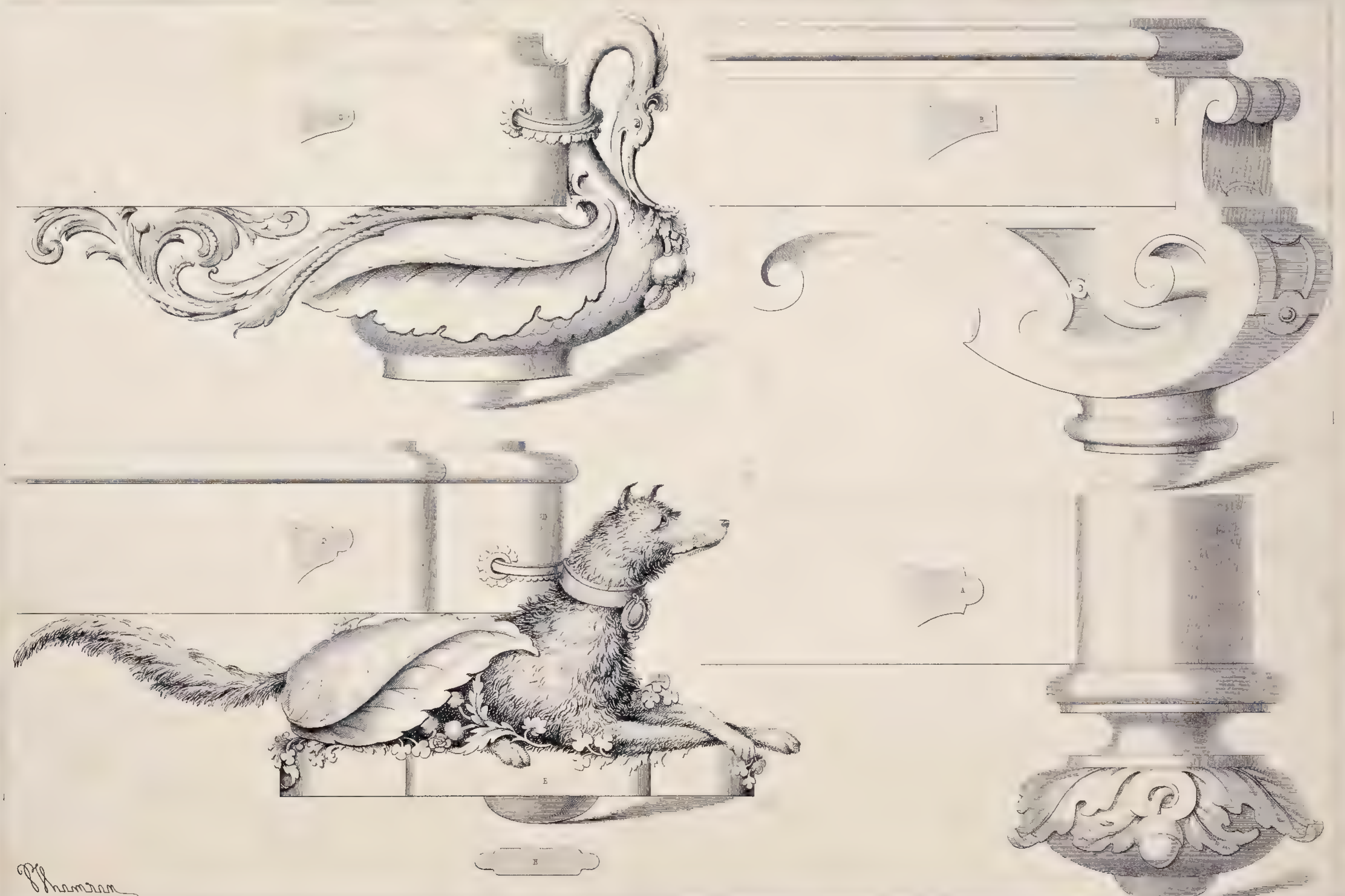


CHAIR SPLITS FULL SIZE



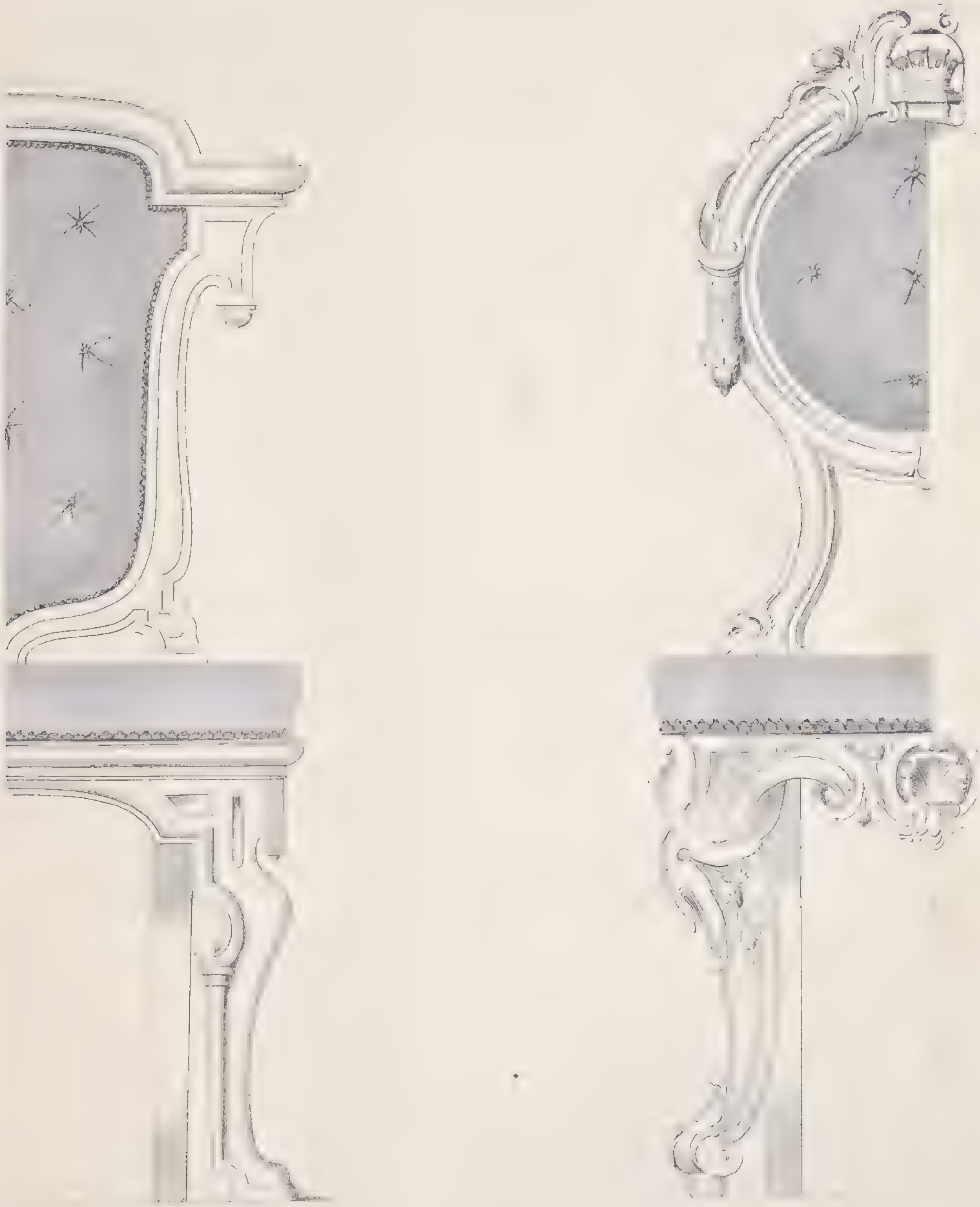
BED & DETAILS

TABLE FEET FOR CARD, FULL, AND LOO, HALF SIZE.



P. Thomson

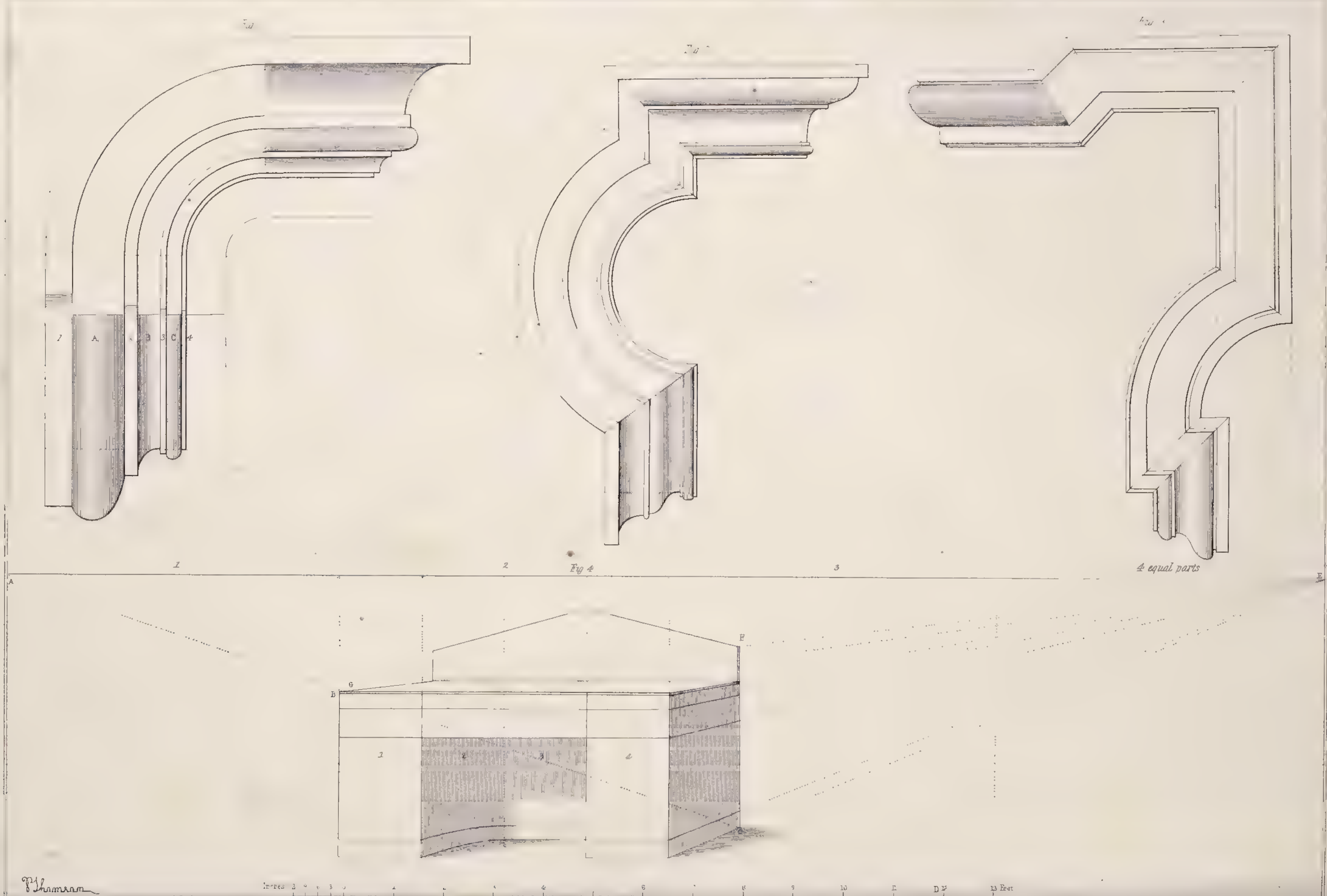
T. Watt



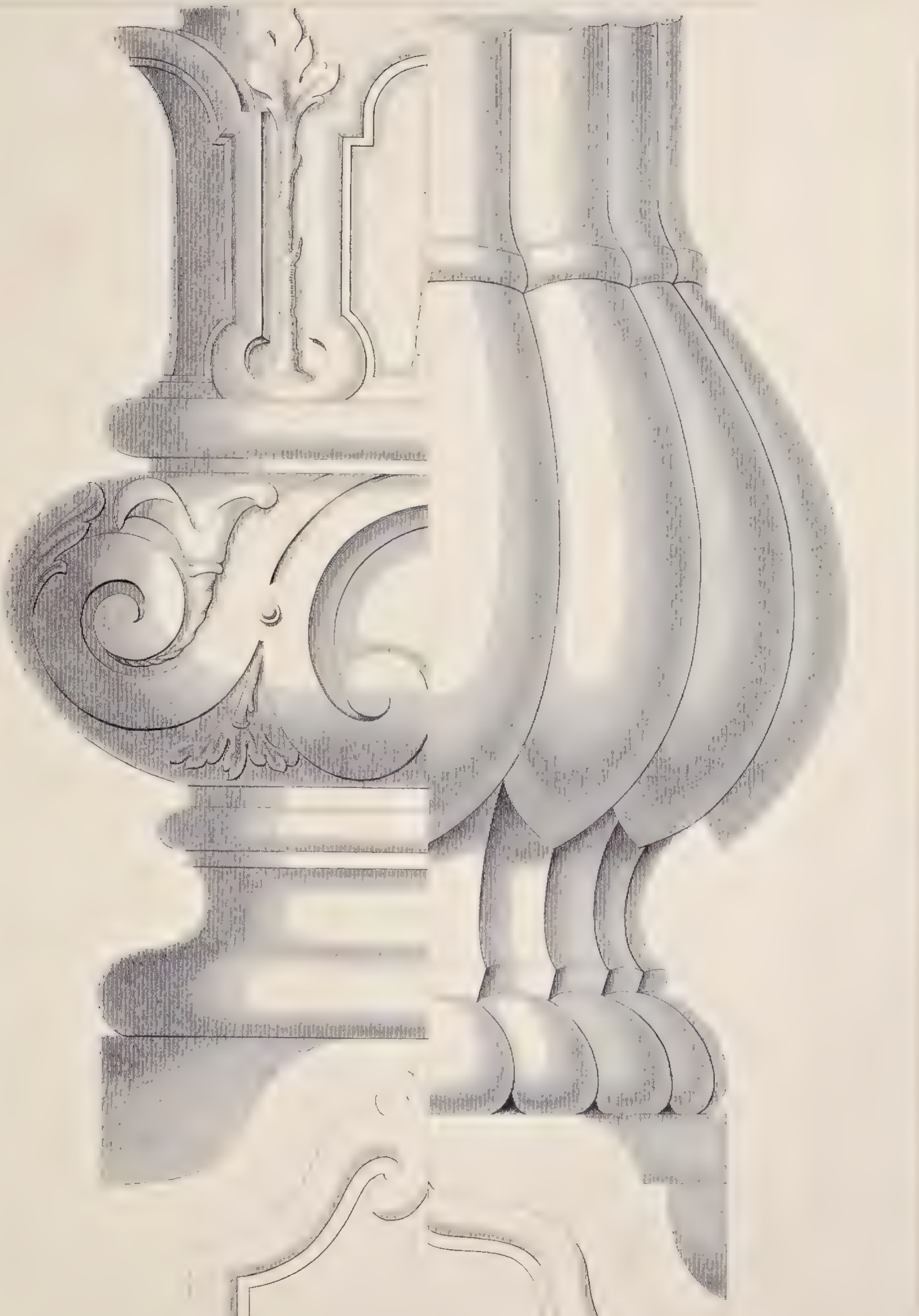
FRET PANELS

BRACKETS FOR CHIFFONNIERES HALF SIZE

WILLIAM MACKENZIE


1
A
B
3
C
4
1
2
Fig 4
3
4 equal parts
A
E
B
G
F
1
2
3
4
D
Inches
Feet

BED PILLARS



P. Thomson

WILLIAM MACKENZIE GLASGOW & EDINBURGH

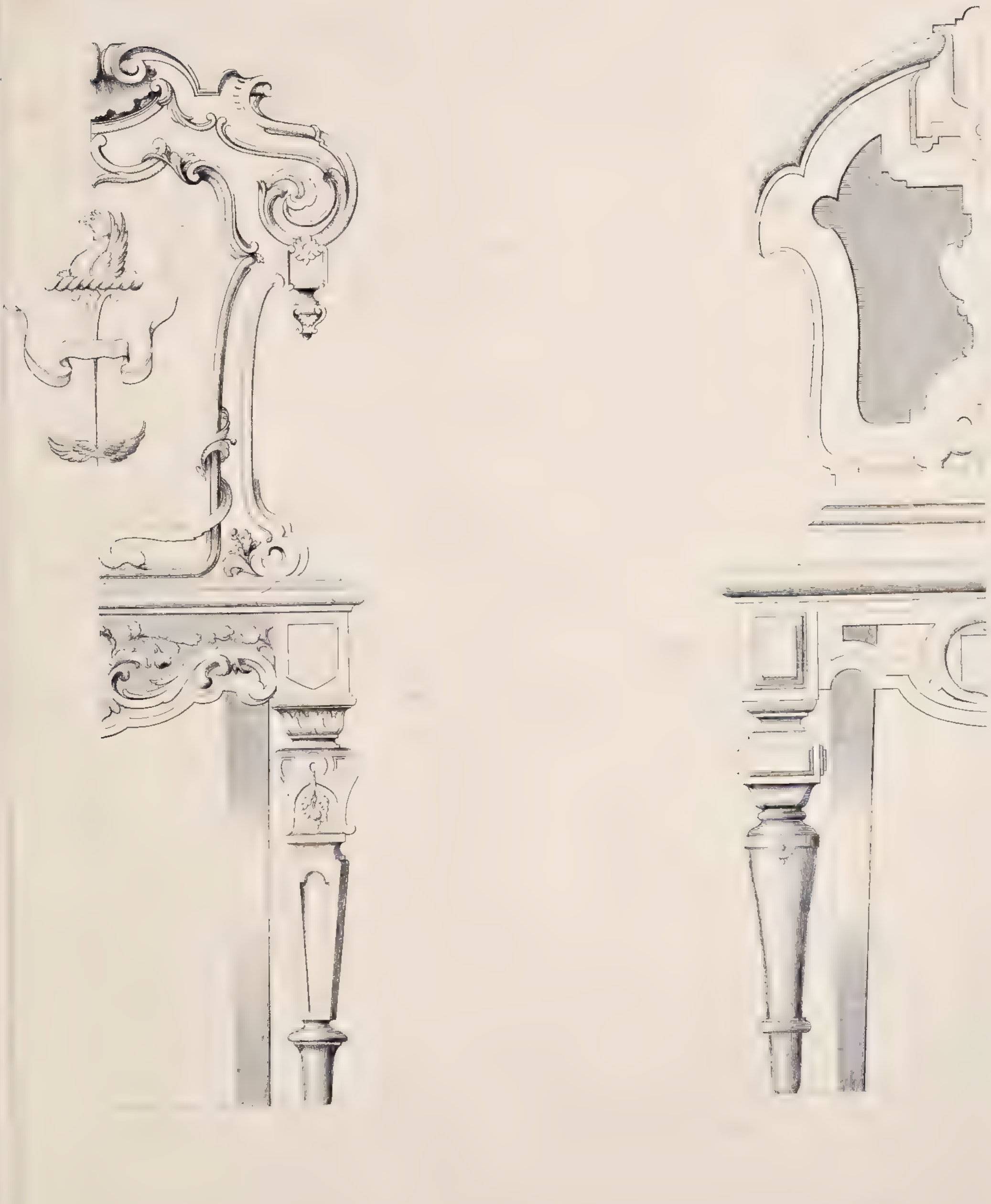
FOOT STOOLS

DETAILS FOR BEDS

WILLIAM MACKENZIE, GLASGOW & EDINB. R.H.

SIDEBOARD DETAILS, STAGES, HALF SIZE

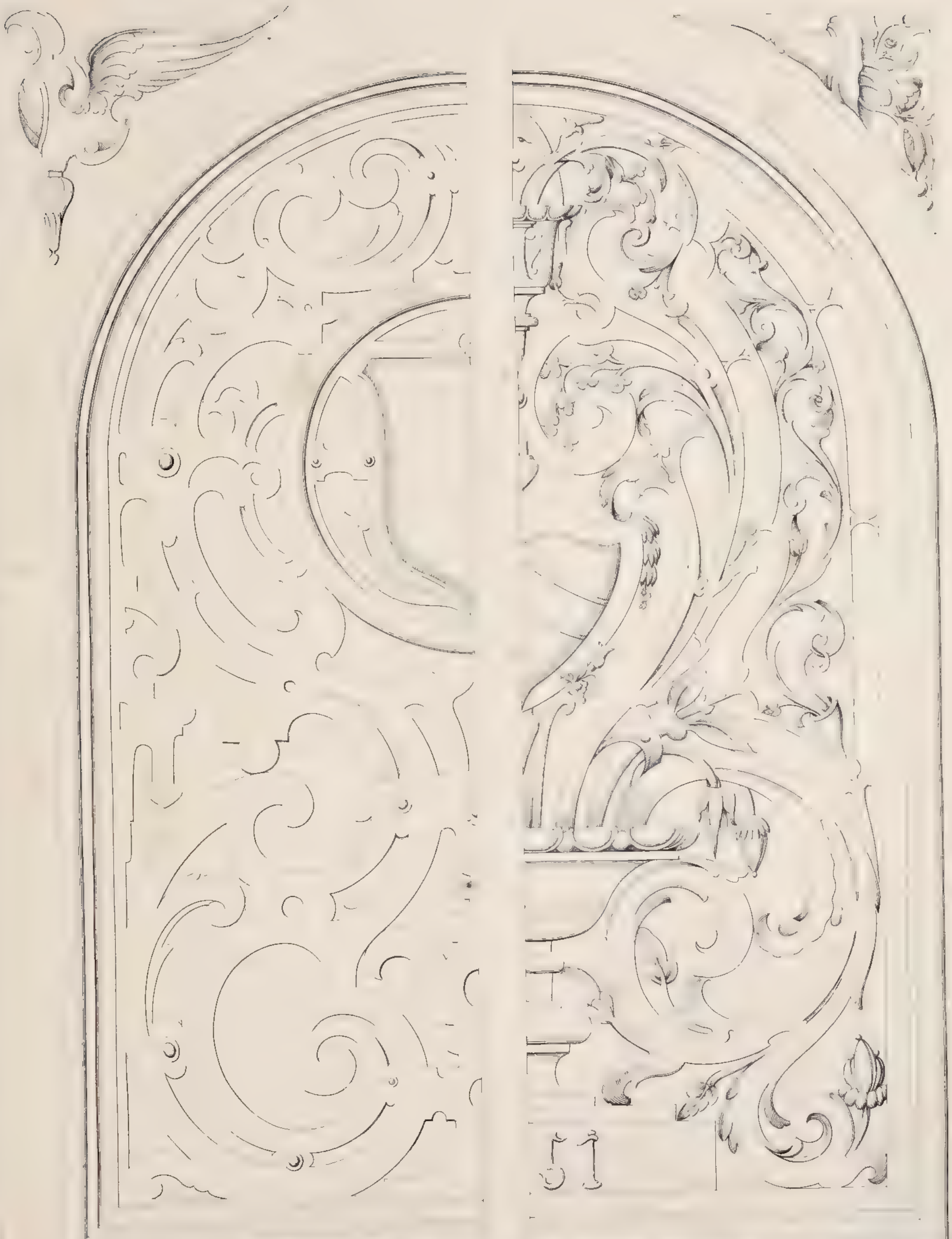
HALL CHAIRS



WILLIAM MACKENZIE, GLASGOW & EDINBURGH

W.

FRET PANELS



HALL TABLE FRONTS

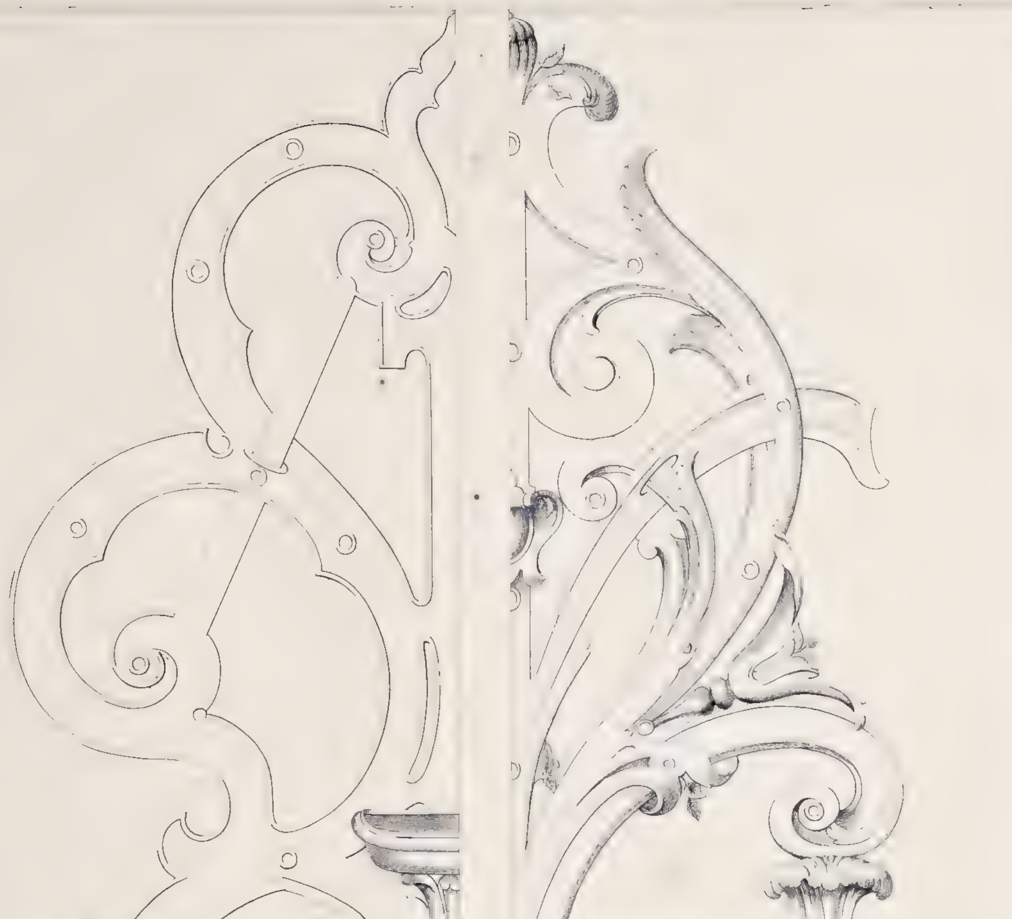
P. Thomson   Inches 12 9 6 3 0 1 2 3 Feet   J. Scott

SOFA DETAILS

WILLIAM MACKENZIE, GLASGOW & EDINB.

WILLIAM MACKENZIE, GLASGOW & EDINBURGH.

HAT STANDS

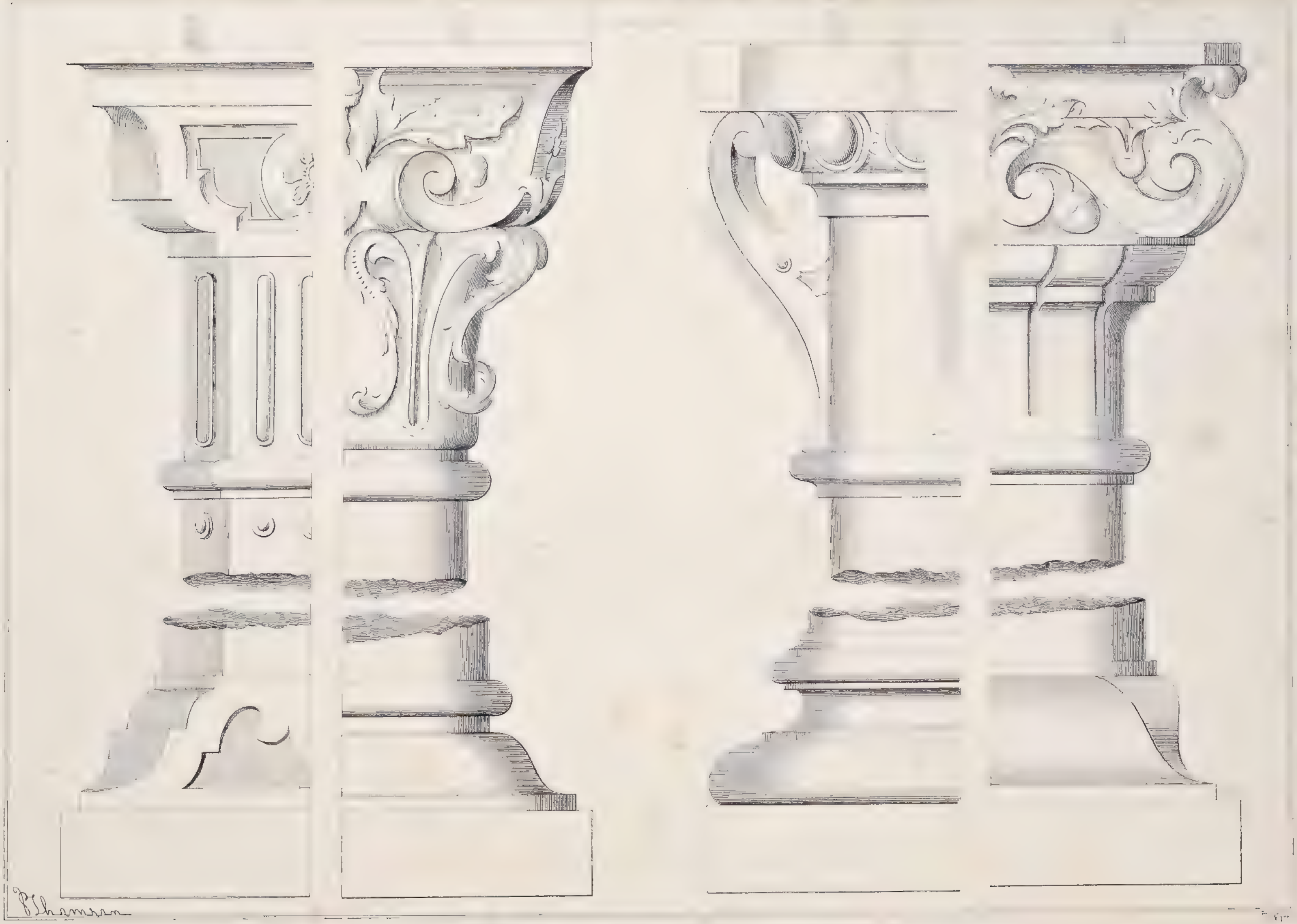


Inches

P. Thamsan

WARDROBE DETAILS

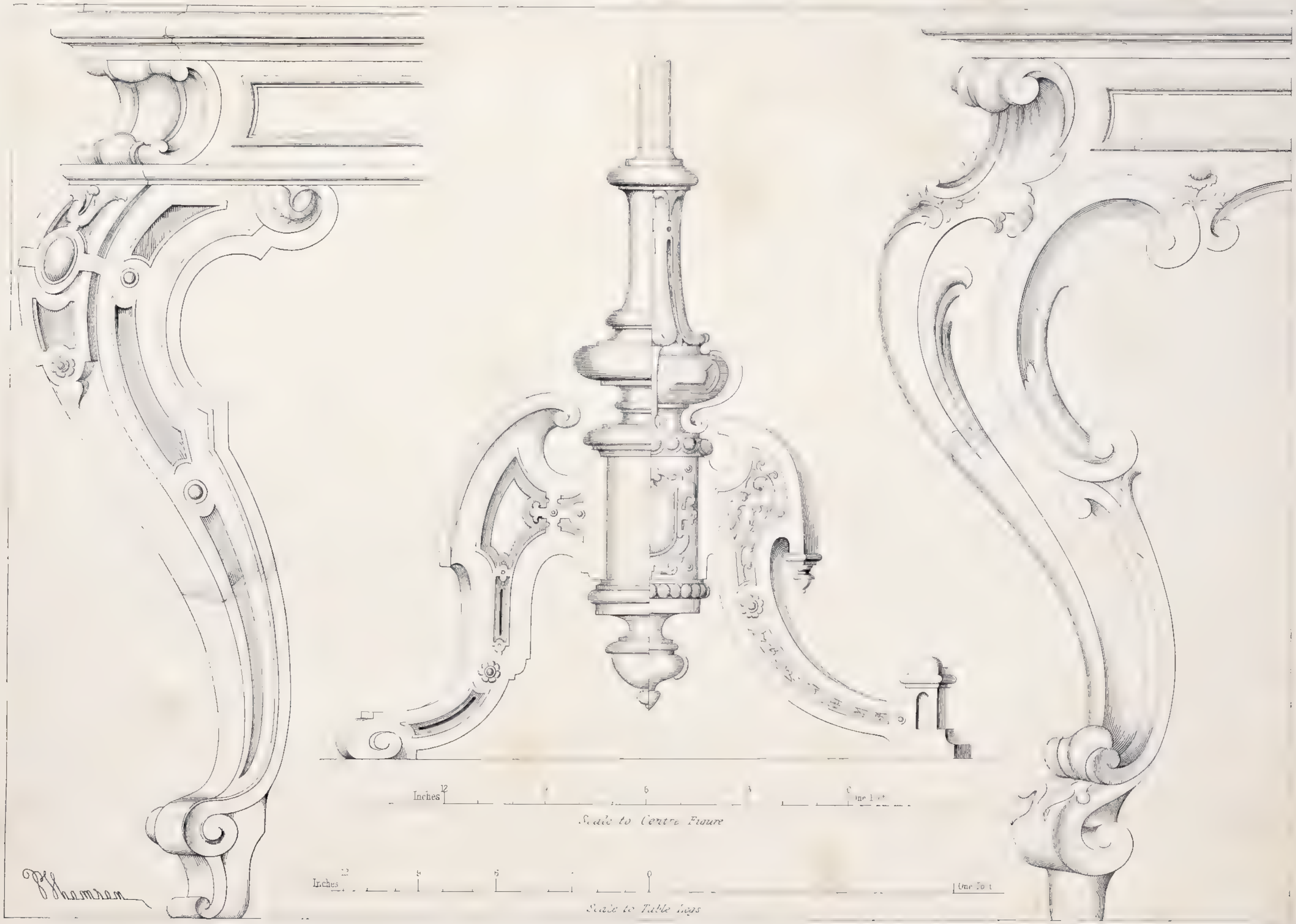
WARDROBE DETAILS



PANELS FOR DOORS

HINTS TO YOUNG TRADESMEN

FIRE SCREEN & TABLE LEGS



WINDOW POLES HALF SIZE

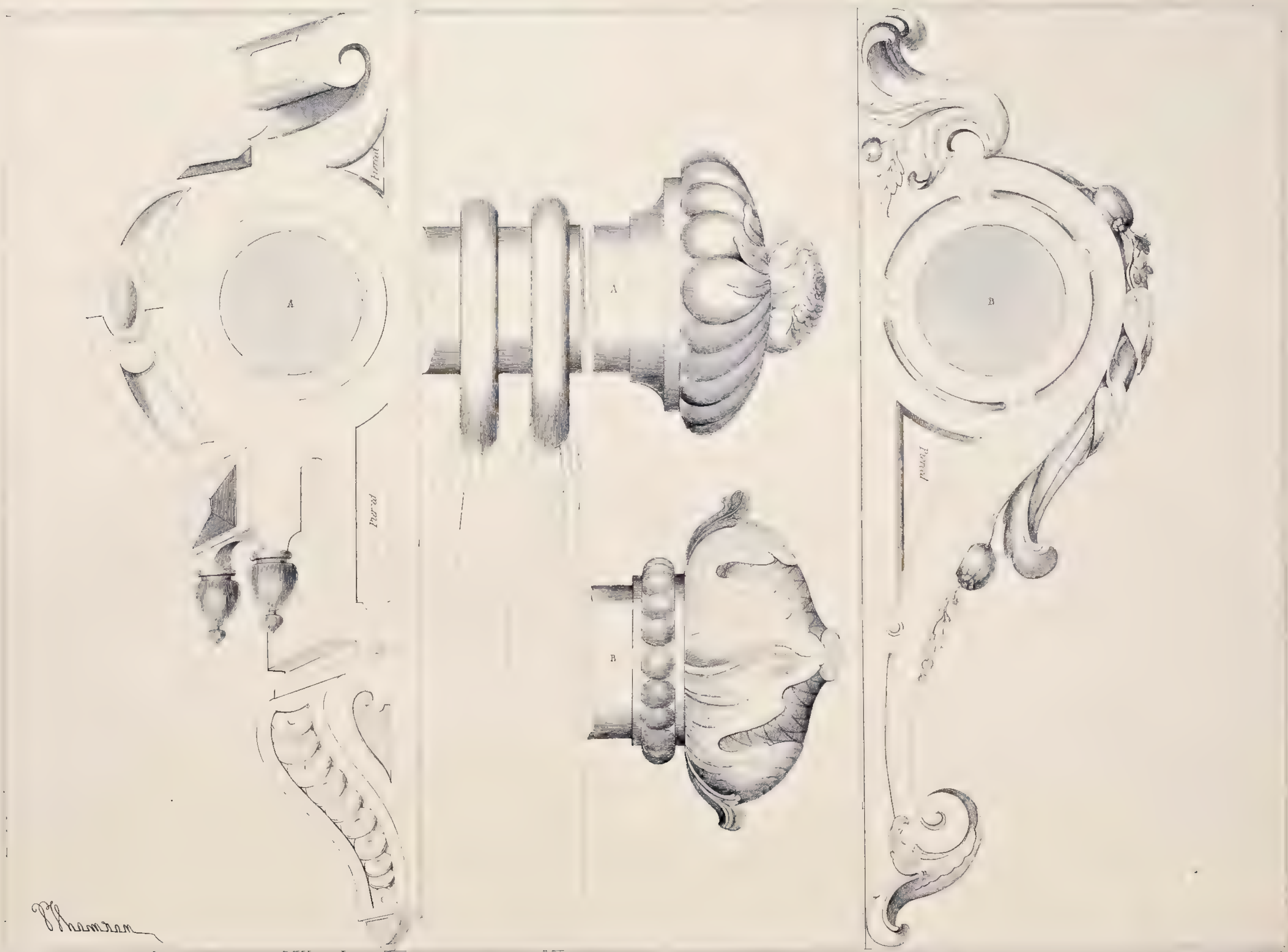
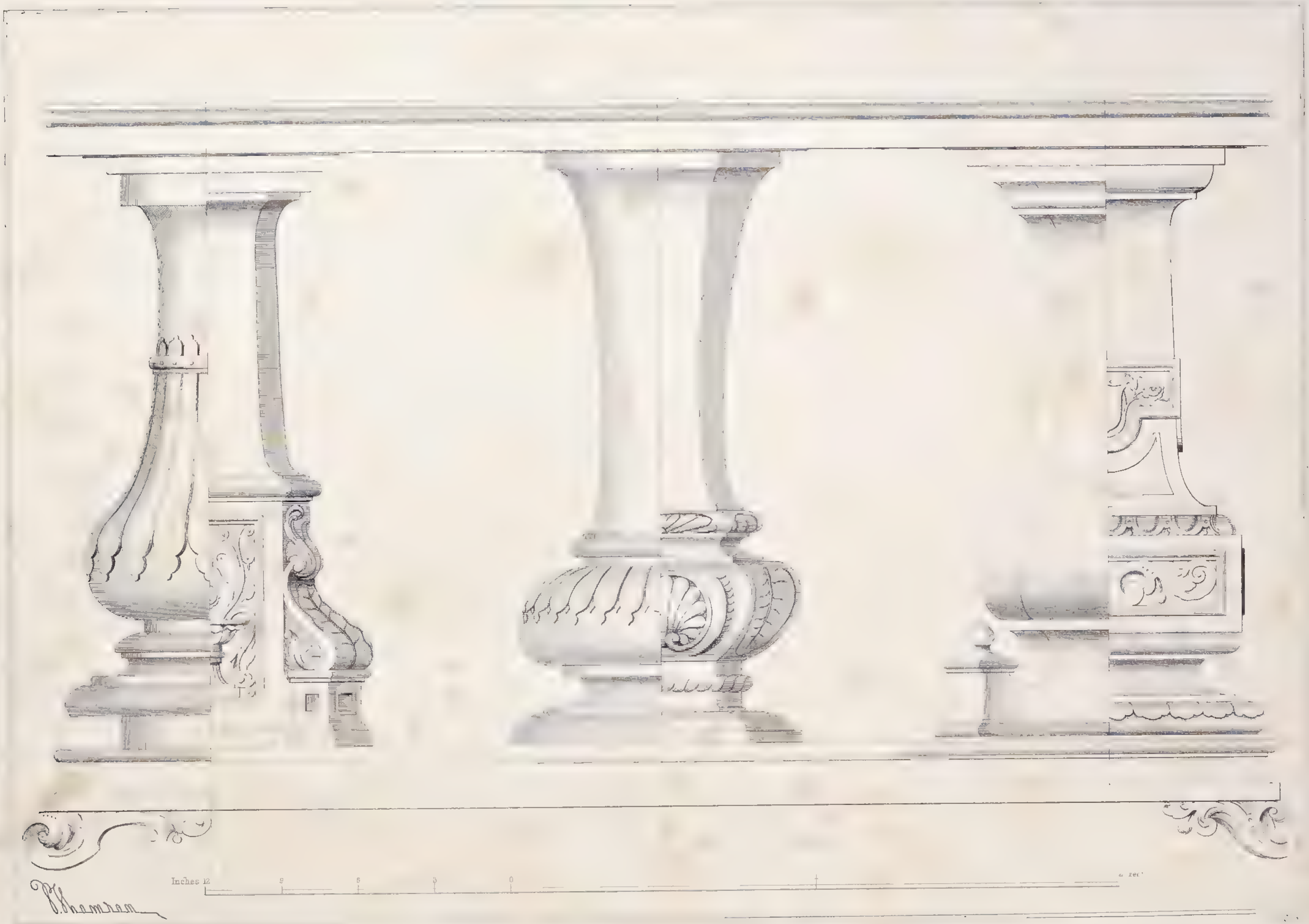


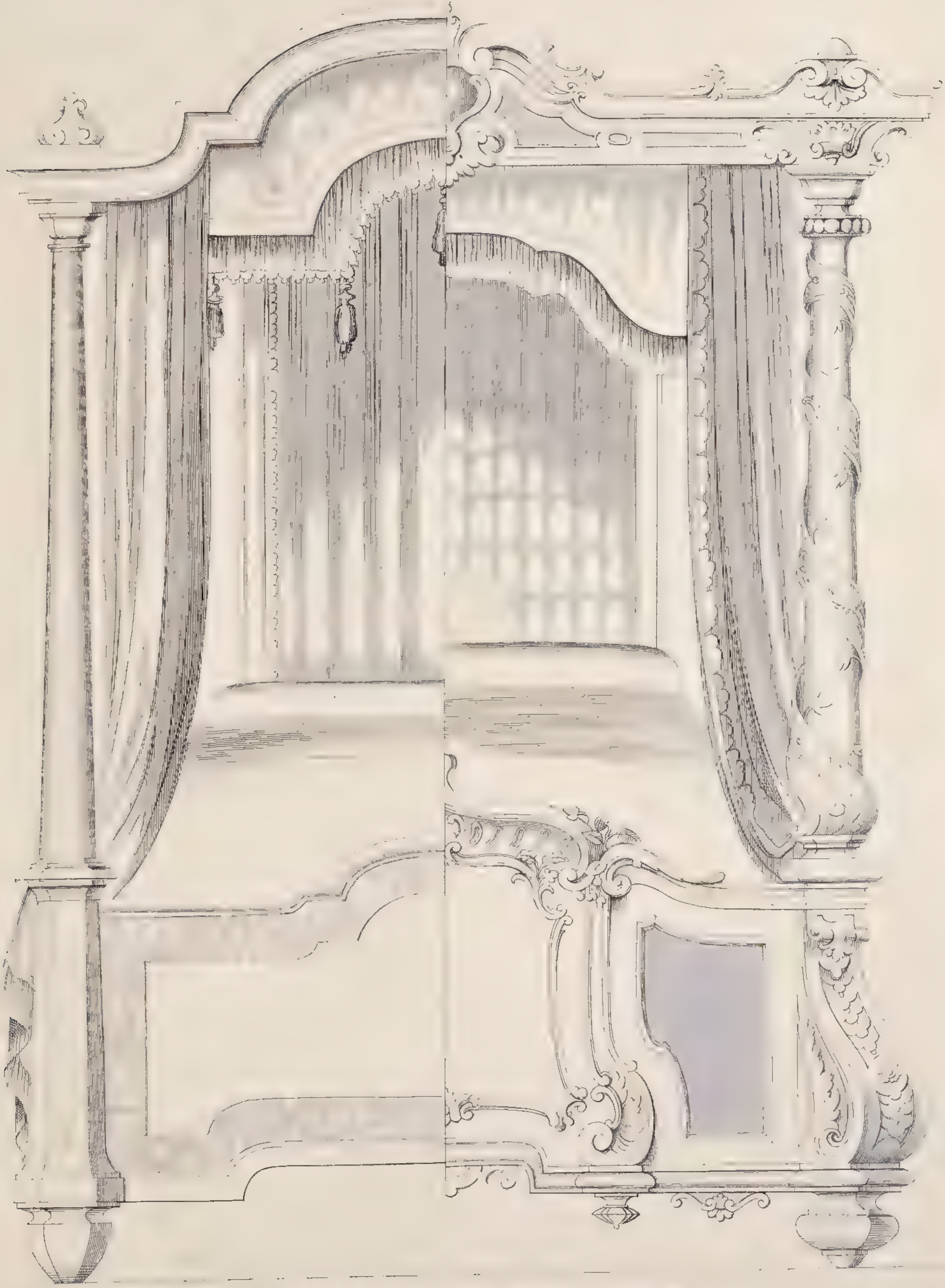
TABLE CLAWS

TABLE PILLARS



WILLIAM MACKENZIE _ GLASGOW EDINBURGH & LONDON

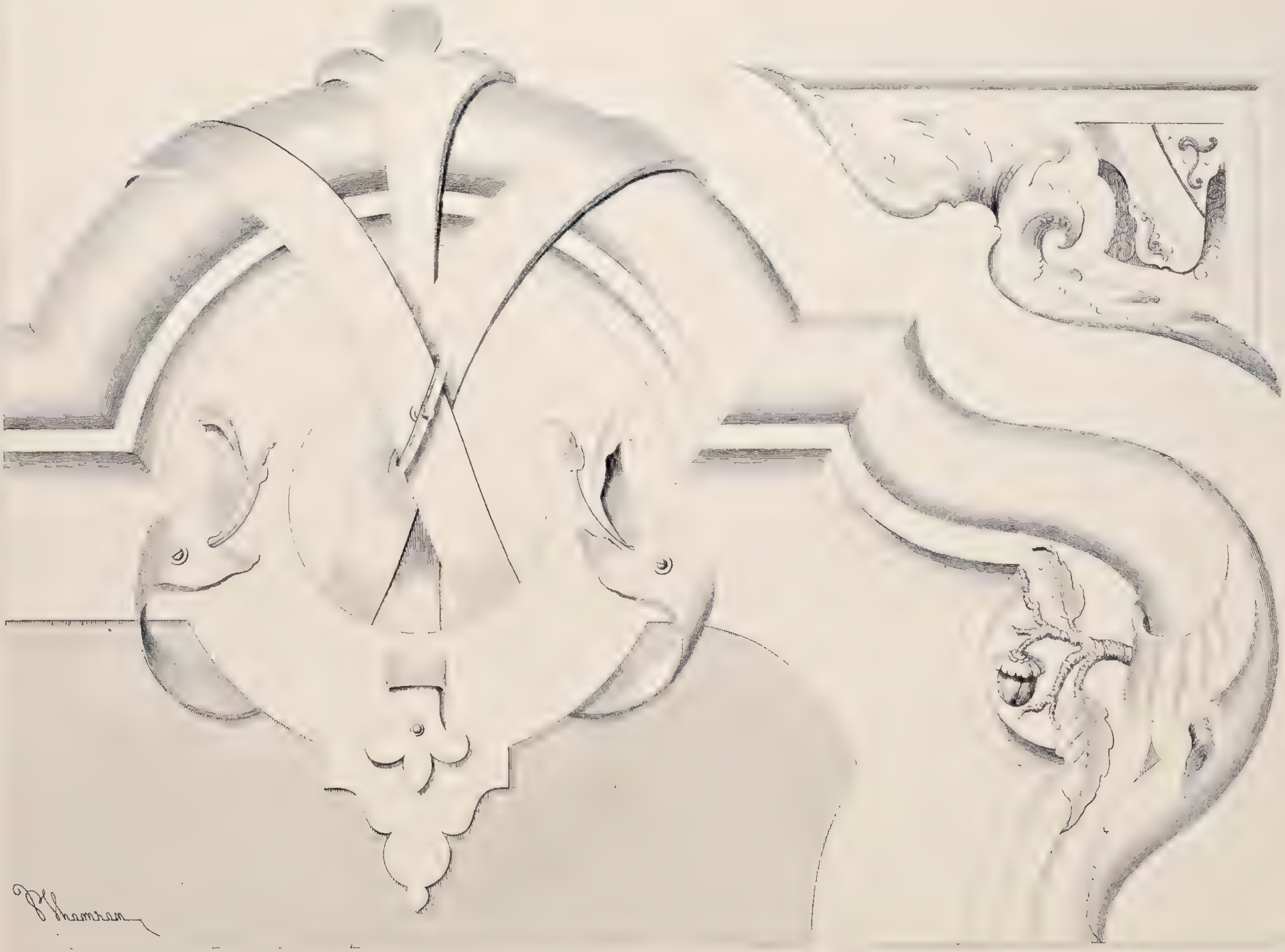
BEDS



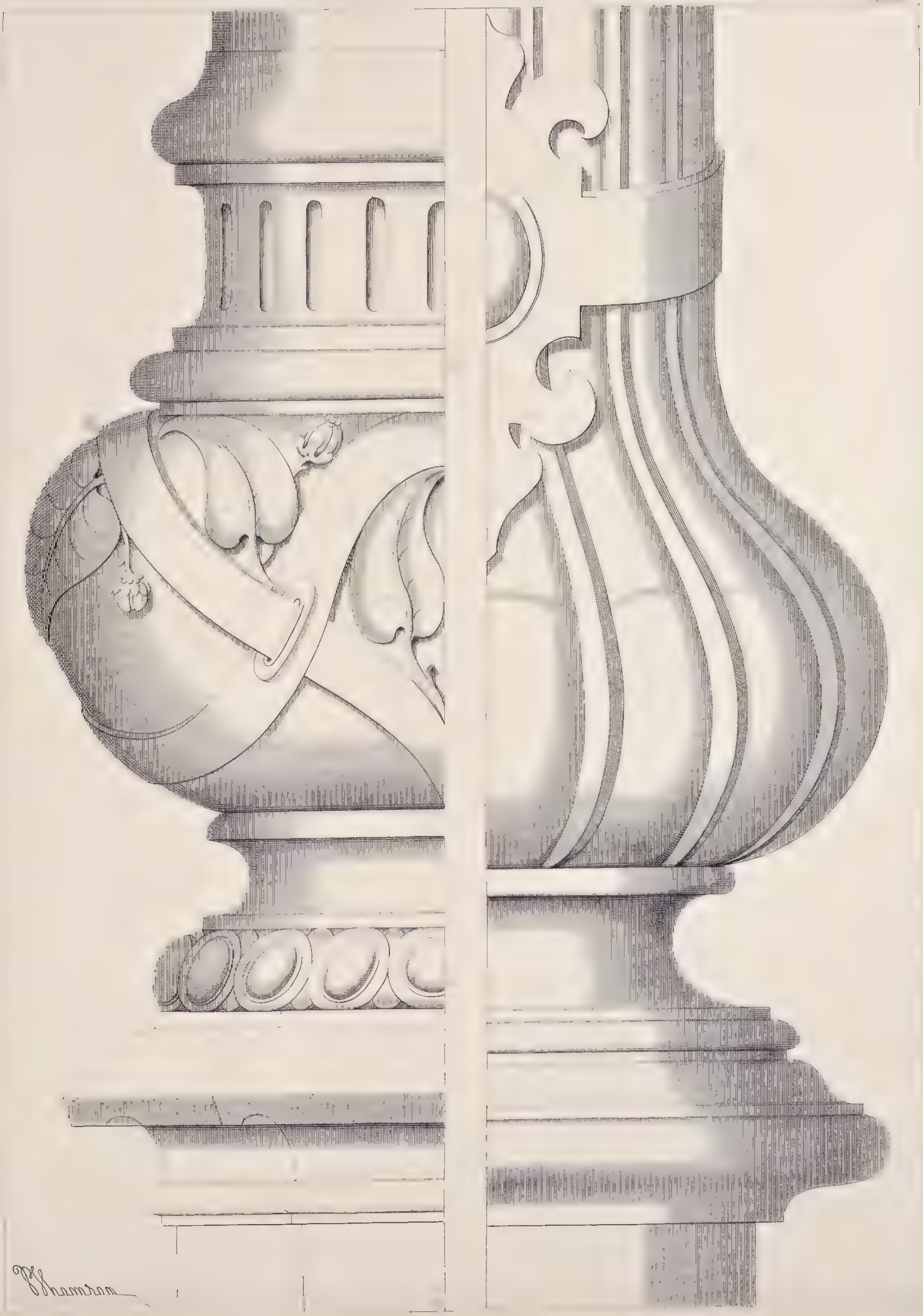
J. Scott

WILLIAM MACKENZIE _ GLASGOW EDINBURGH & LONDON

BACK OF HALL CHAIR



BED PILLARS



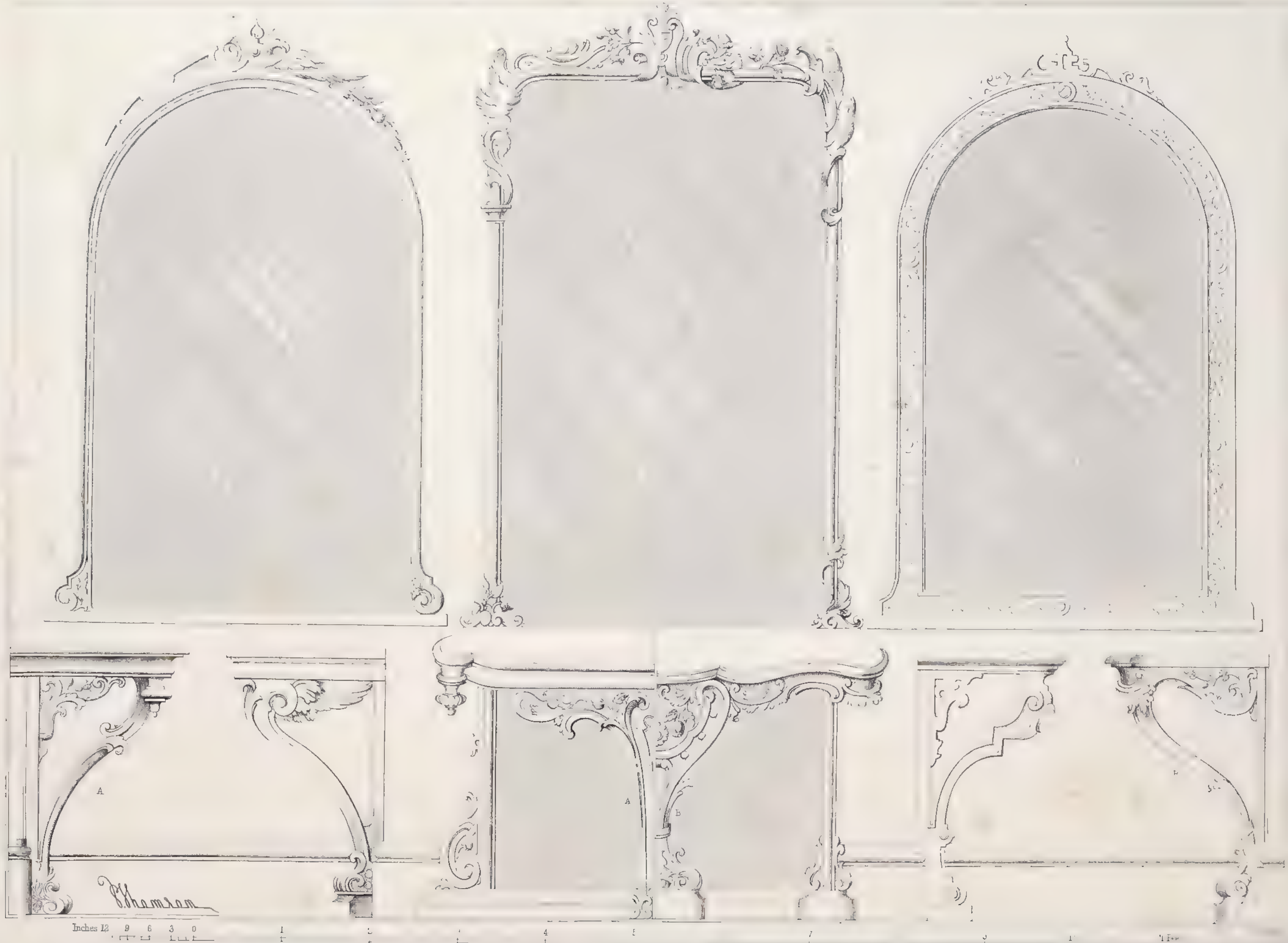
FIRE SCREENS

FIRE SCREENS

W[illegible]AM MAC[illegible]N[illegible] [illegible] NB[illegible] [illegible]N[illegible]

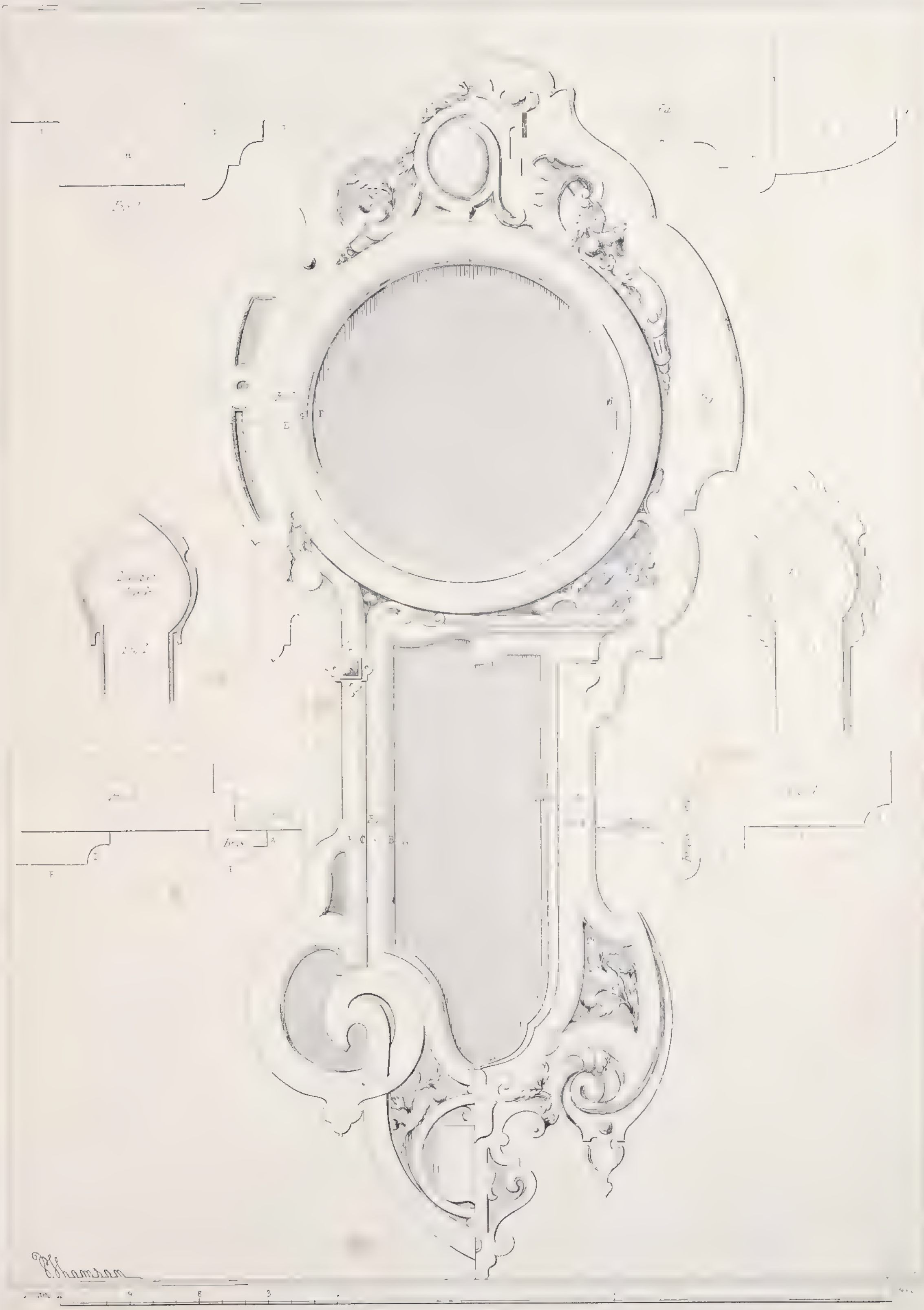
WILLIAM MACKENZIE, GLASGOW, EDINBURGH & LONDON.

BRACKETS & GLASS FRAMES OVER



BRACKETS

HALL CLOCK & DETAILS

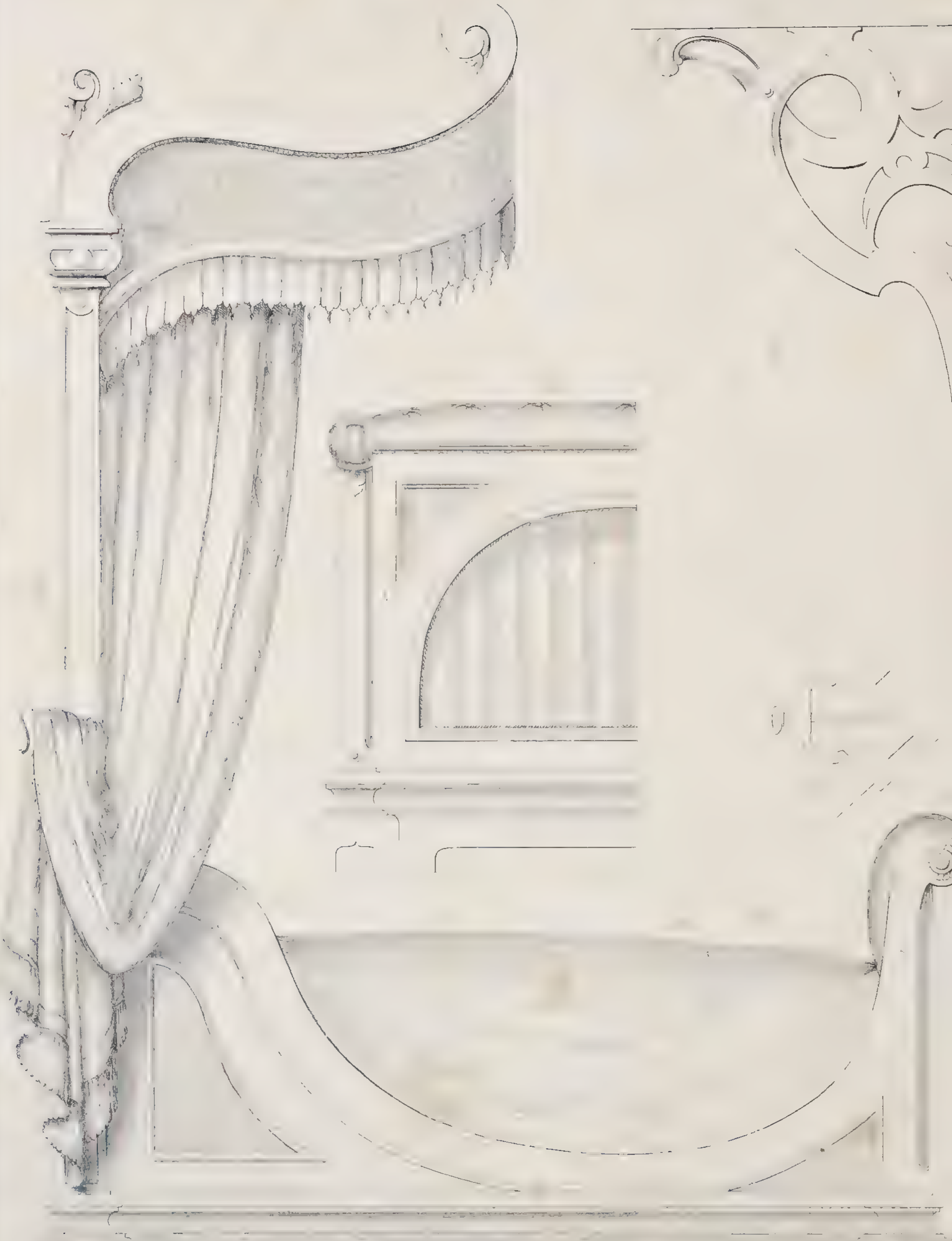


P. Thomson

CURTAIN POLE ENDS

WILLIAM MACKENZIE, GLASGOW, EDINBURGH & LONDON

HALF



R BEDS

SINGLE WARDROBE

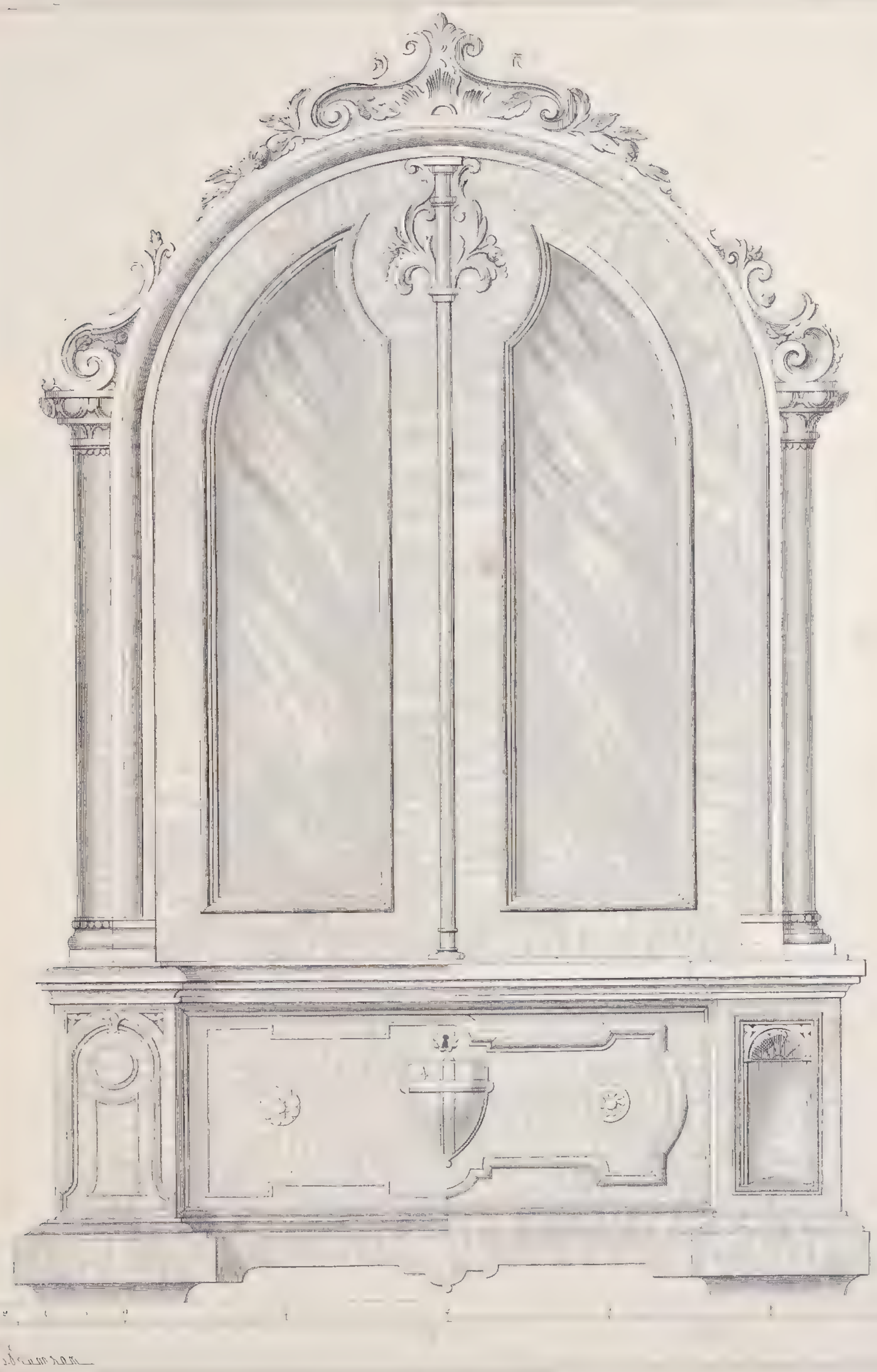
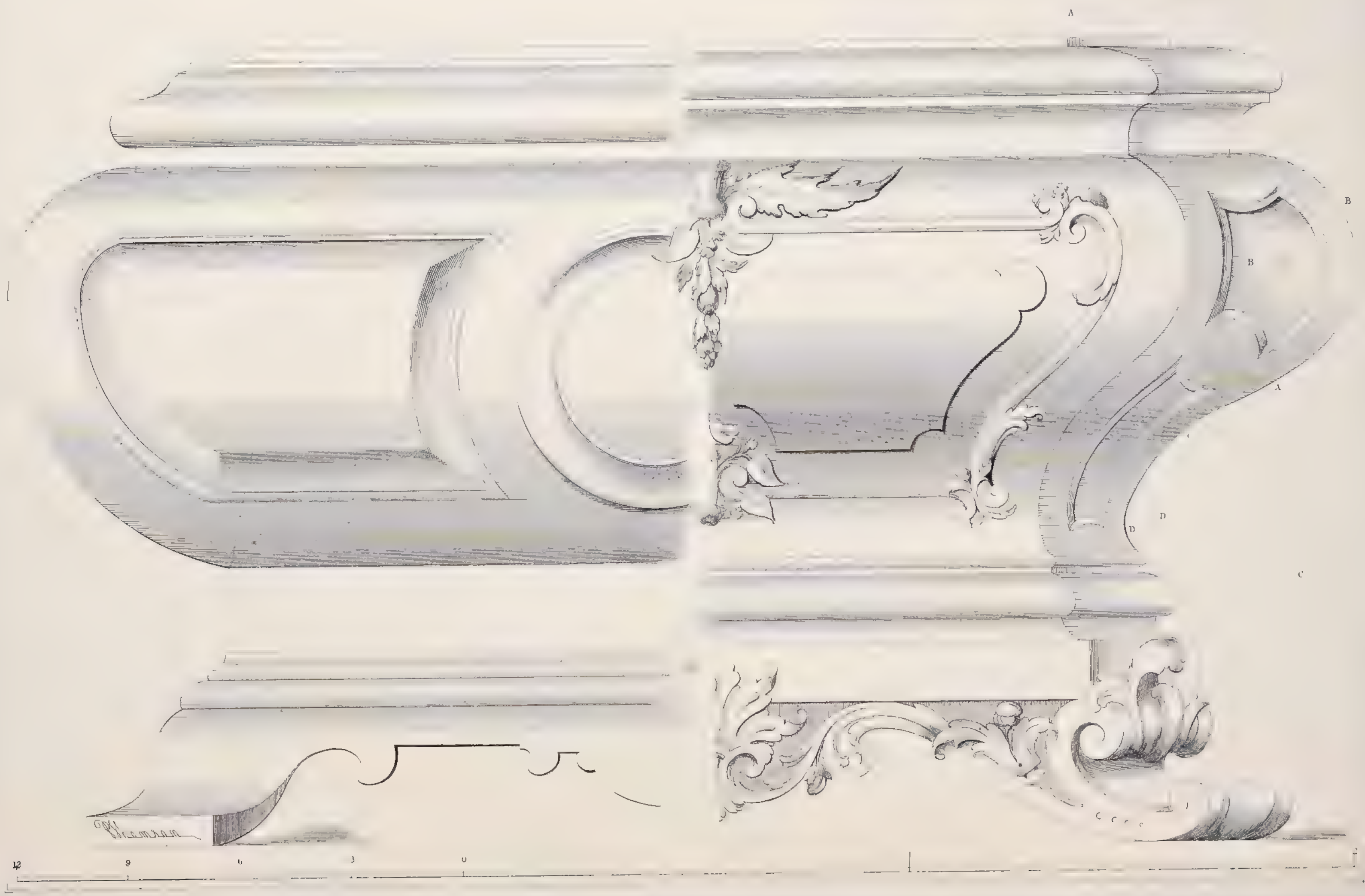


TABLE FRAME OR SIDEBOARD STAGE

(HINTS FOR YOUNG TRADESMEN)

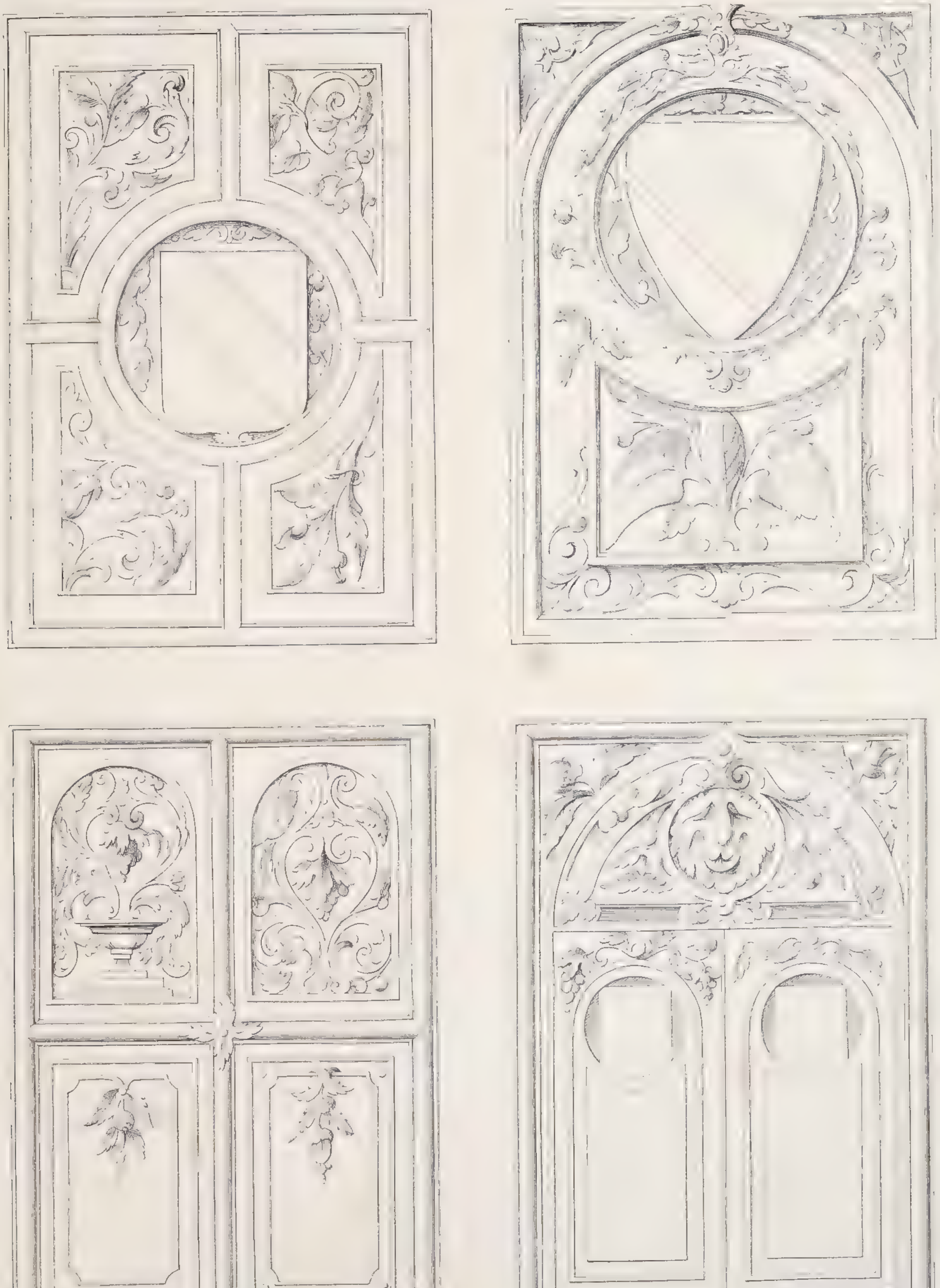
WILLIAM MACKENZIE _ GLASGOW, EDINBURGH & LONDON

WINE COOLERS



CORNICE MOULDINGS

PANNELLING
(HINTS TO YOUNG TRADESMEN)



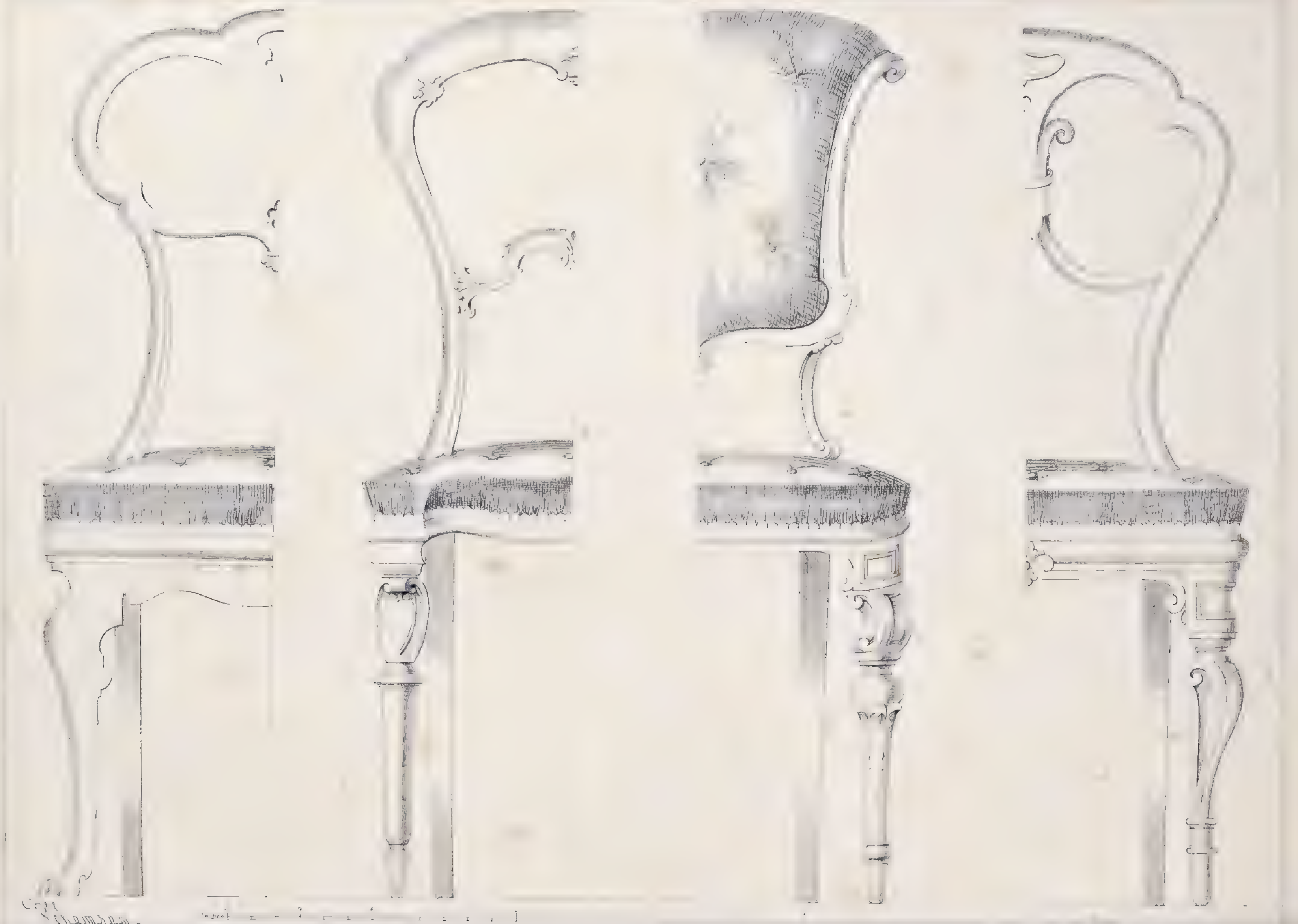
Thomson

SIDE TABLE

THIS TABLE

must be drawn from the wall when required for a Large Party. The centre circular back folds down when out. Two supporters are hinged on the back of the part which folds down when the back is flat, There might be a double back one half to fold to the front upon the top and the other to fold to the back which would form a Round Table. The Use of this Table is to hold the Dishes which may be required on the Centre or Dinner Table There ought to be two of these Tables in a Dining Room, one placed on each side of the Sideboard

DINING ROOM CHAIRS



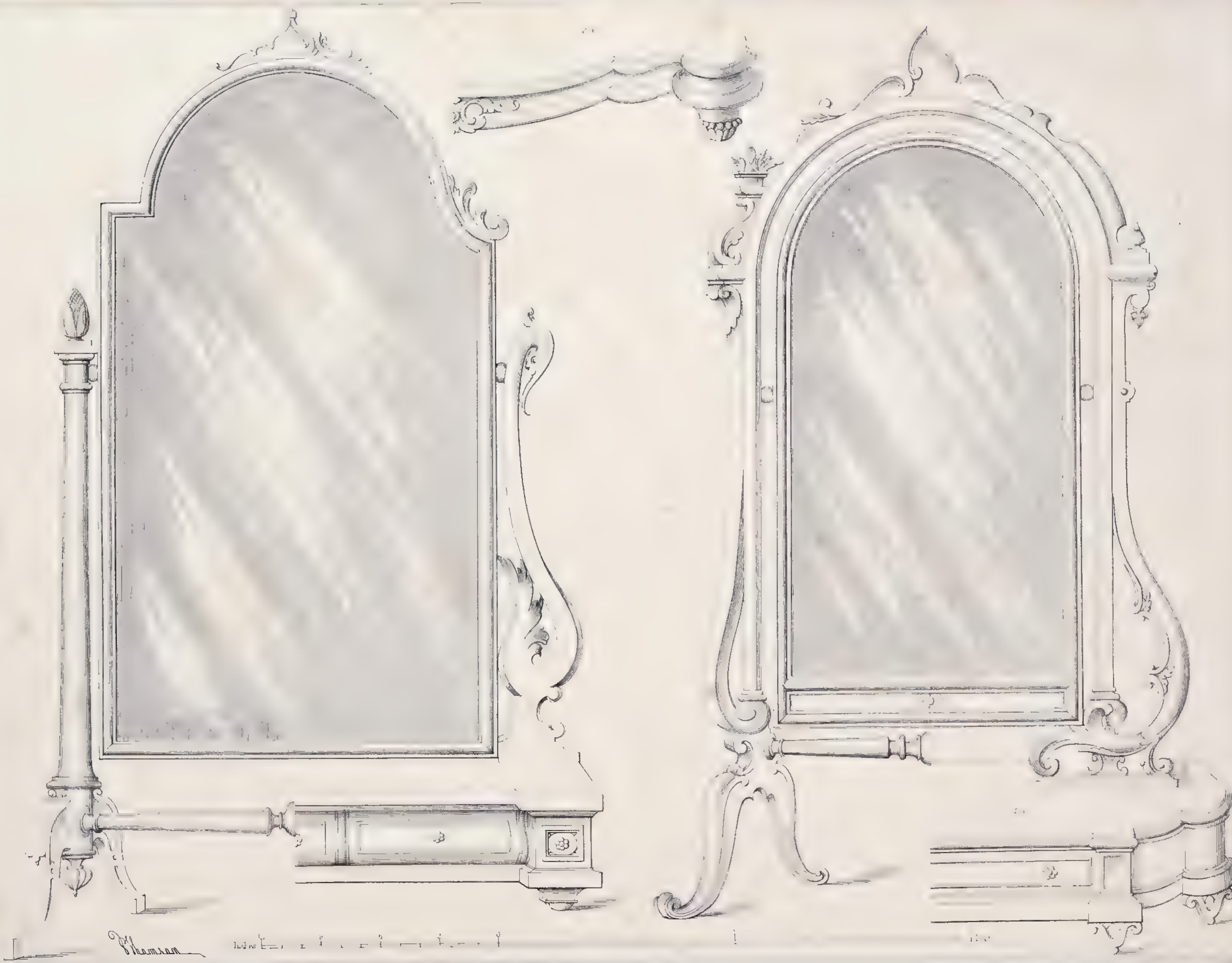
WARDROBE DETAILS_DOORS

P. Thomson

W Warwick

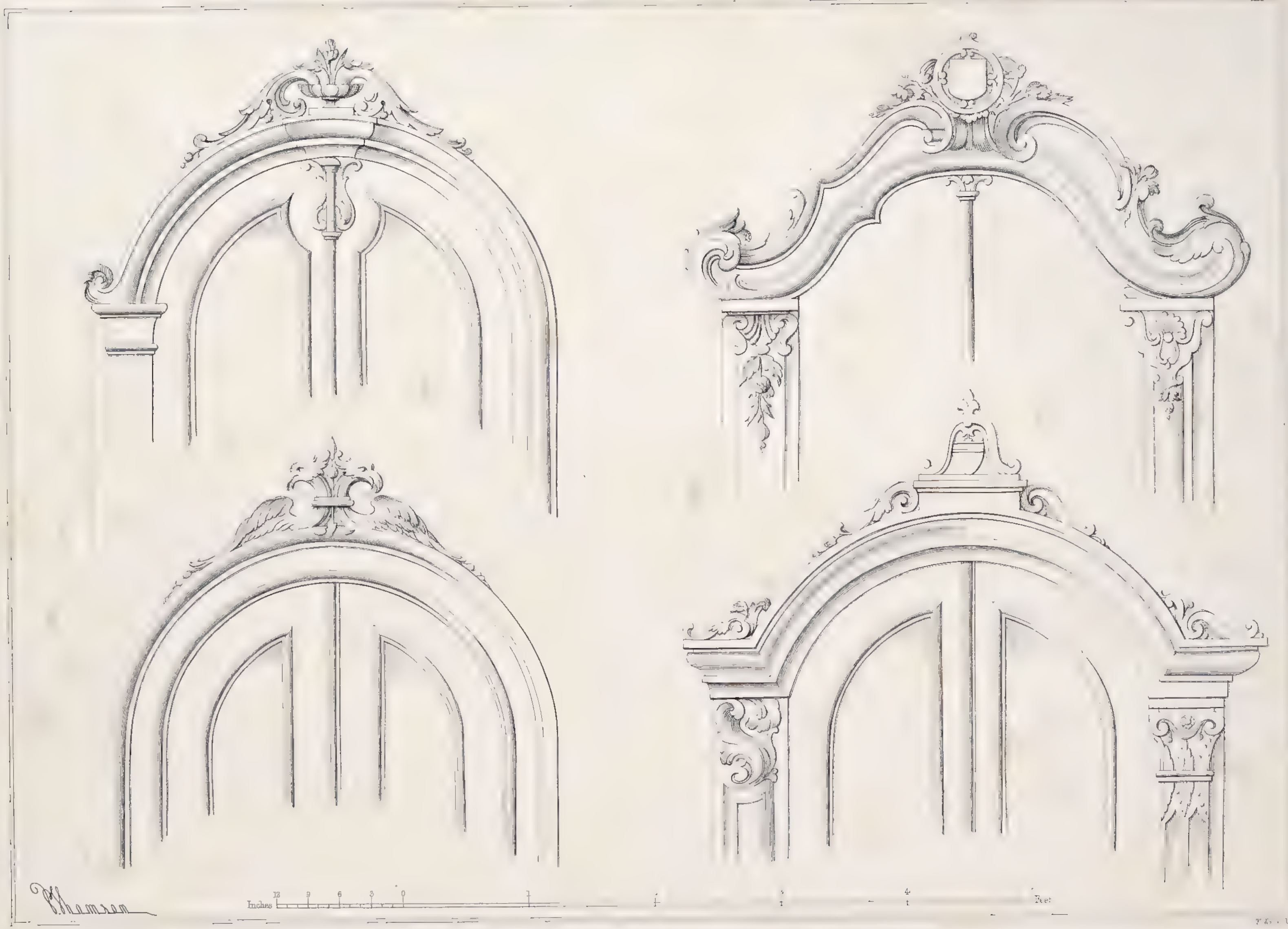
WILLIAM MACKENZIE, LONDON

DRESSING GLASSES

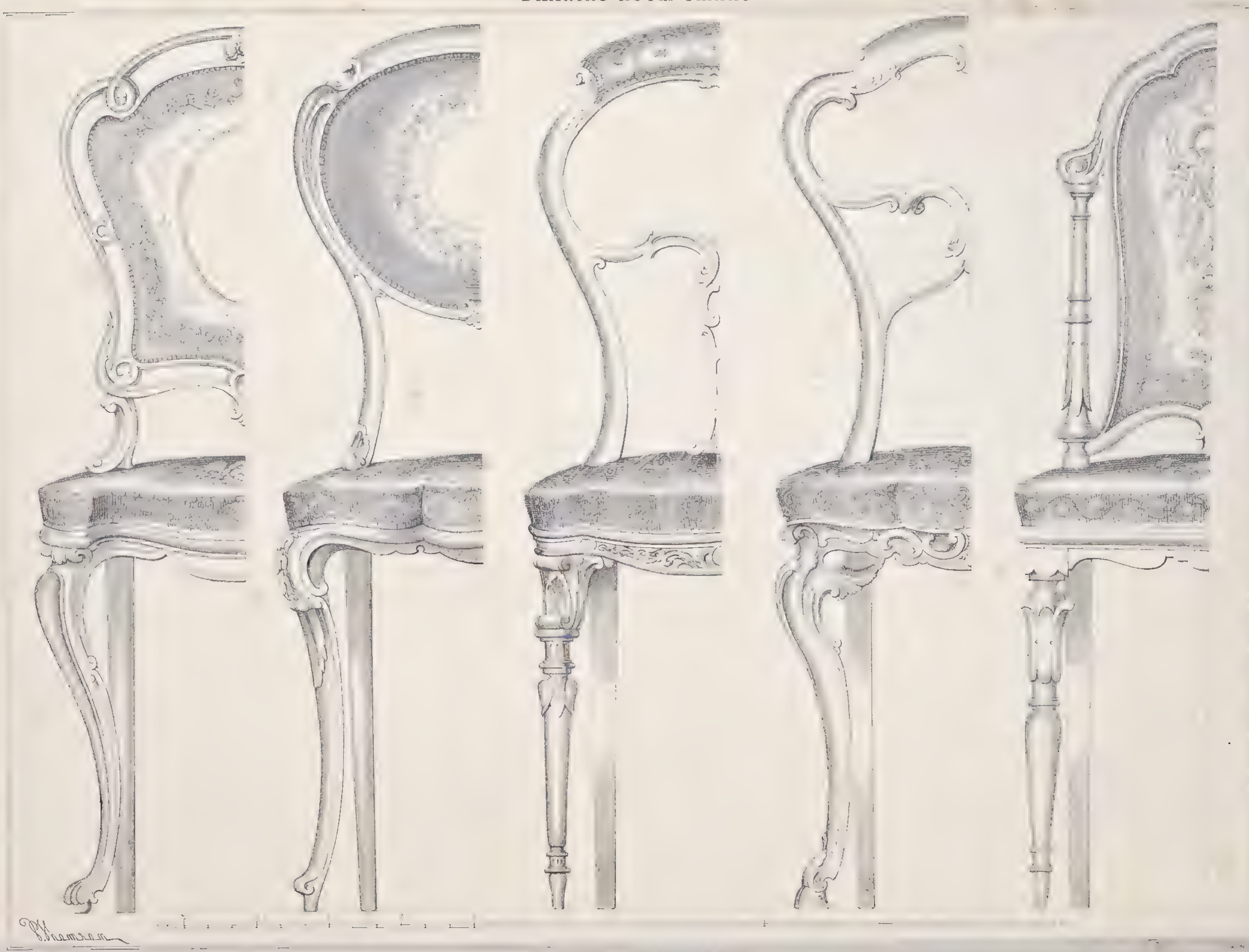


WILLIAM MACKENZIE GLASGOW EDINBURGH & LONDON

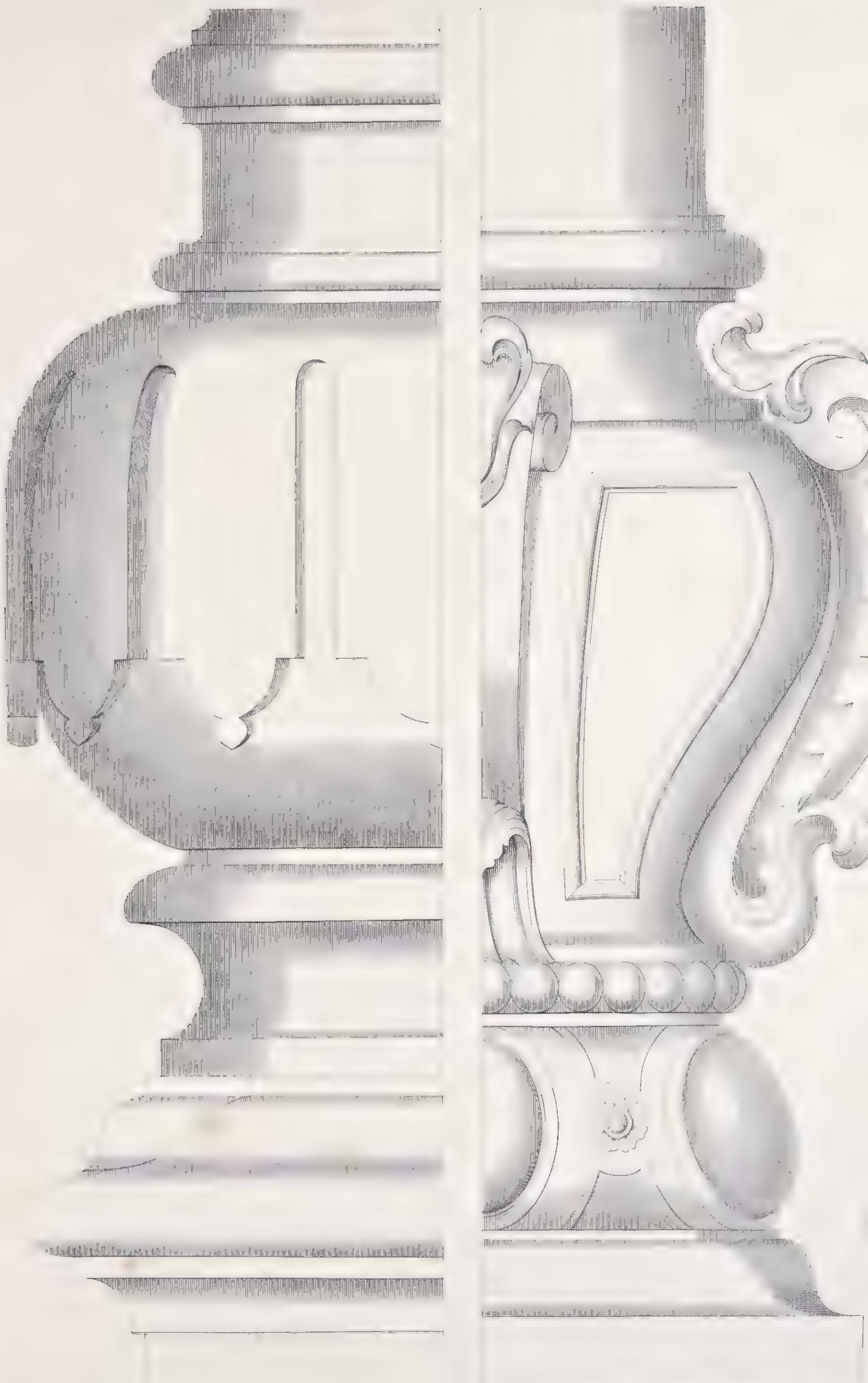
WARDROBE TOPS



DRAWING ROOM CHAIRS



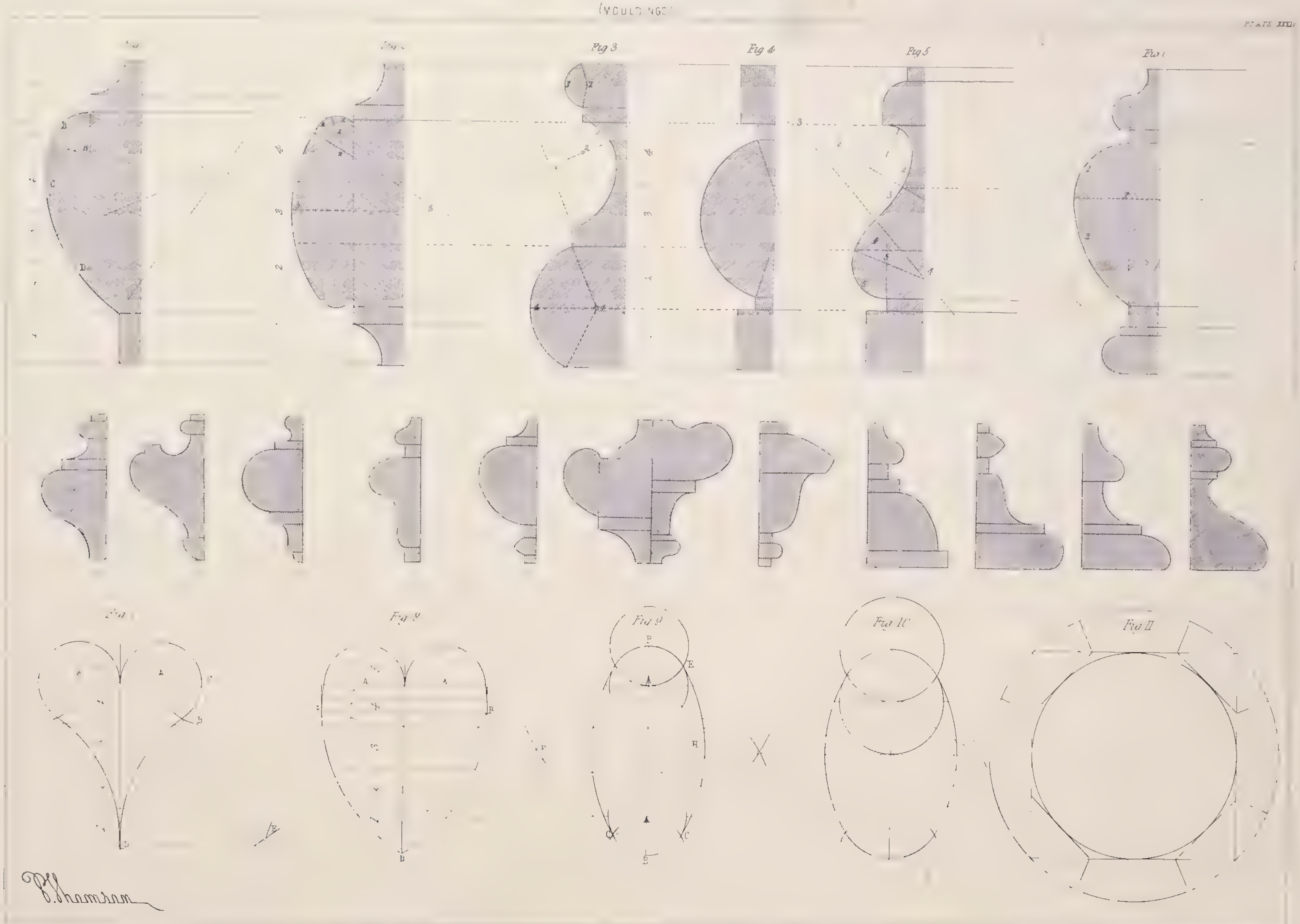
BED PILLARS



P Thomson

HINTS FOR YOUNG TRADESMEN

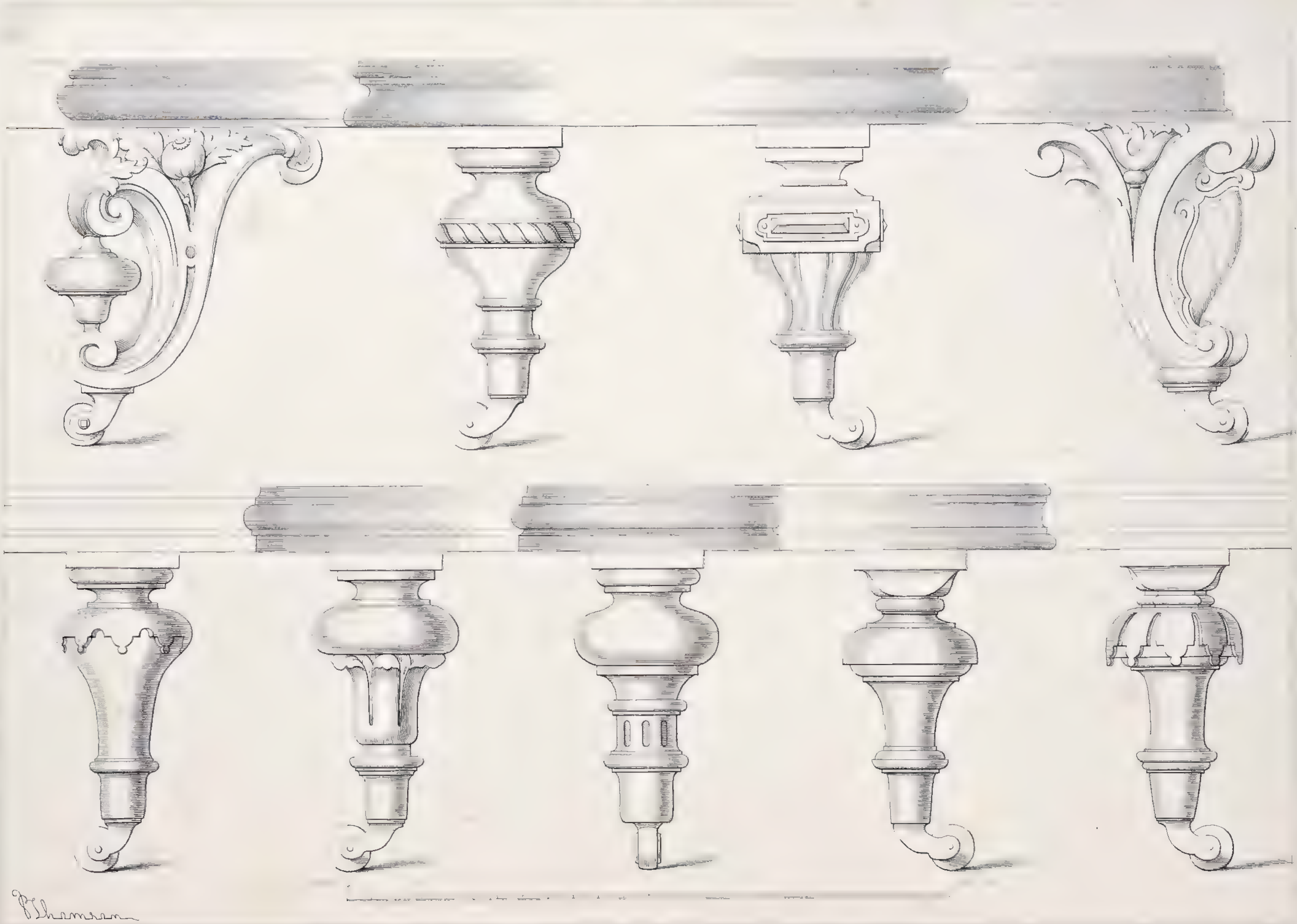
(MOULDINGS)



J. Scott

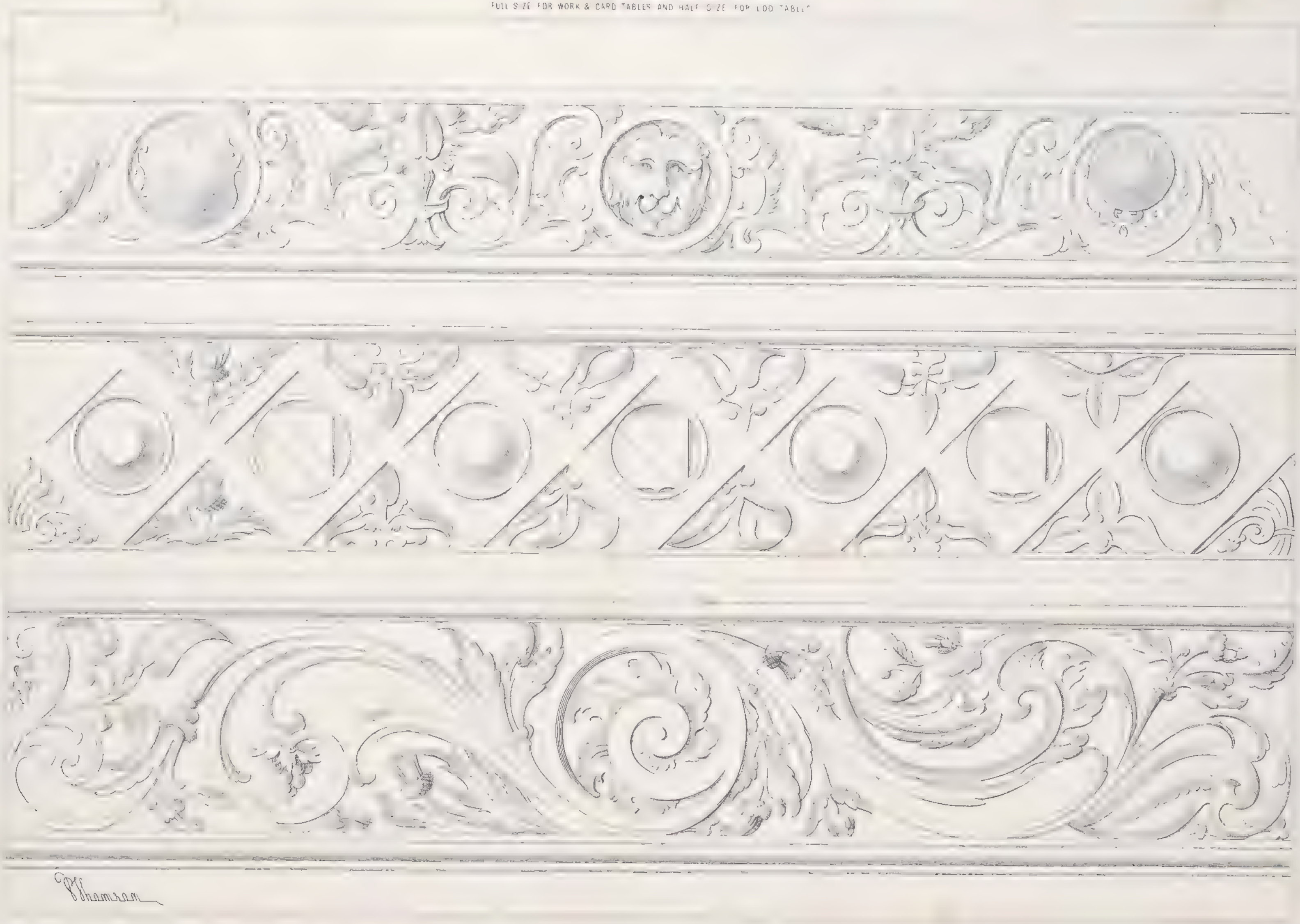
WILLIAM MACKENZIE GLASGOW & EDINBURGH

SOFA LEGS

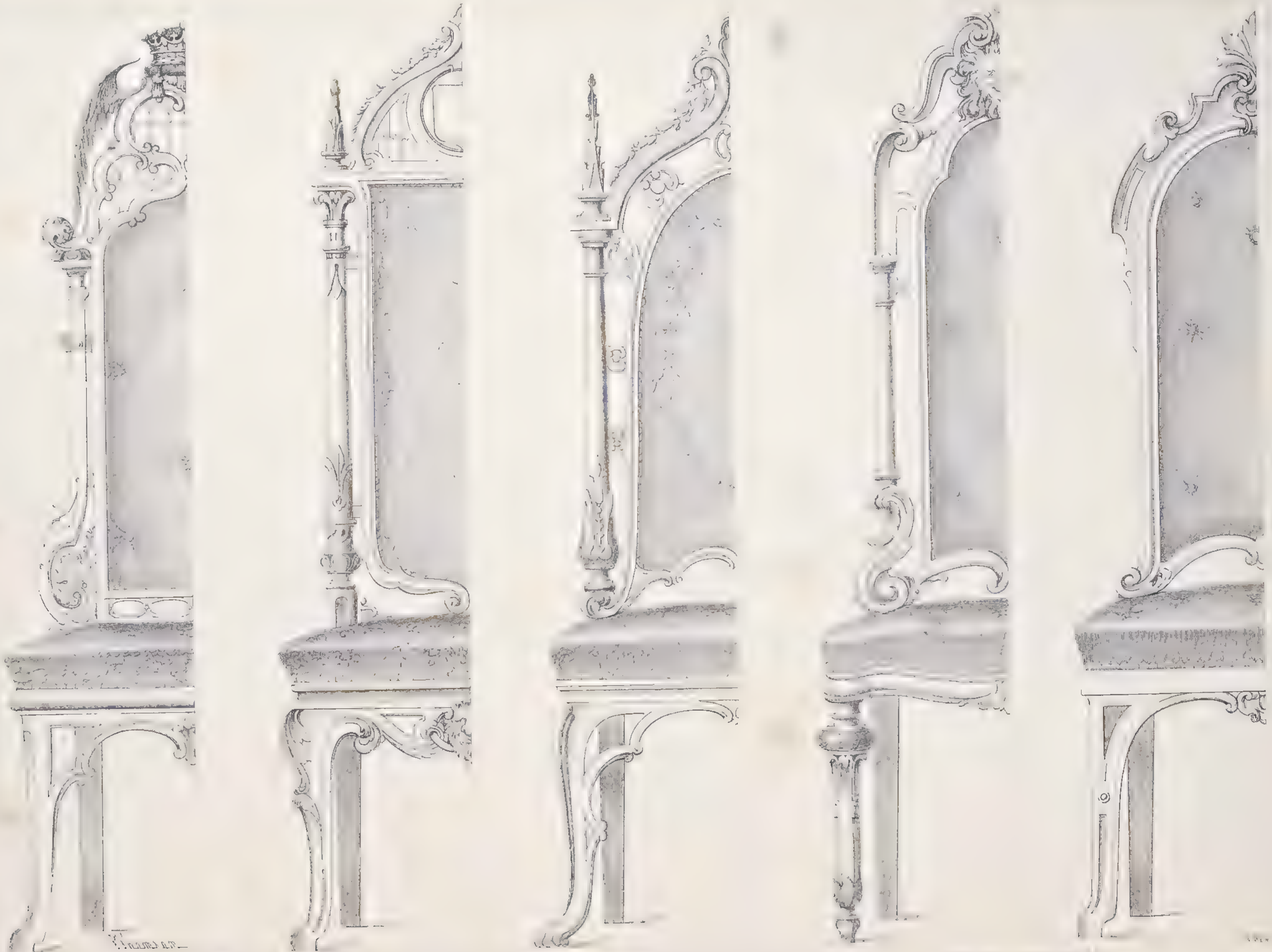


DRAWING ROOM TABLE RIMS

FULL SIZE FOR WORK & CARD TABLES AND HALF SIZE FOR LOO TABLE



SALOON CHAIRS



Feet

P. Thomson

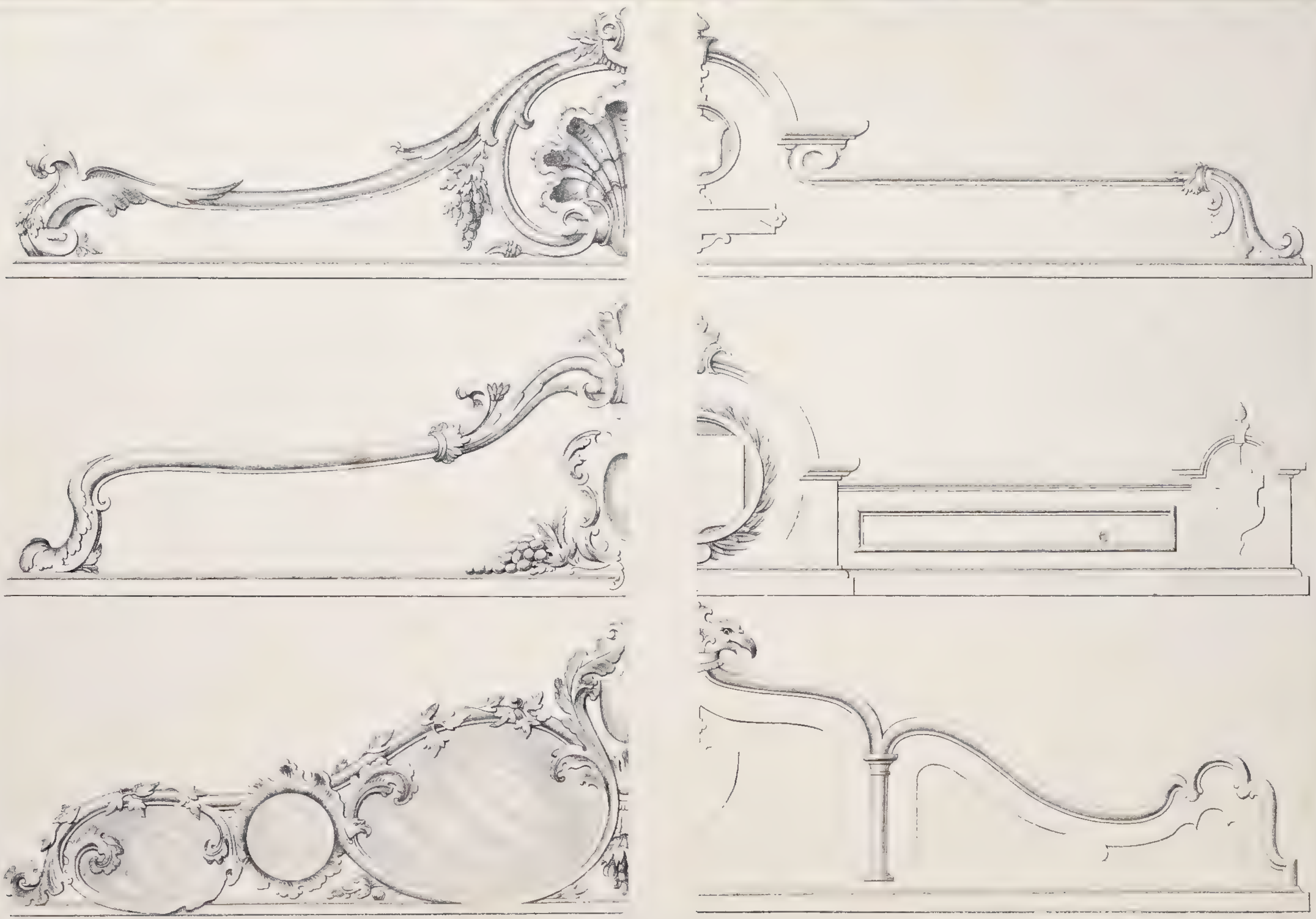
R. Lawson

WILLIAM MACKENZIE, GLASGOW, EDINB^H & LONDON

RAILINGS FOR PUBLIC OFFICES

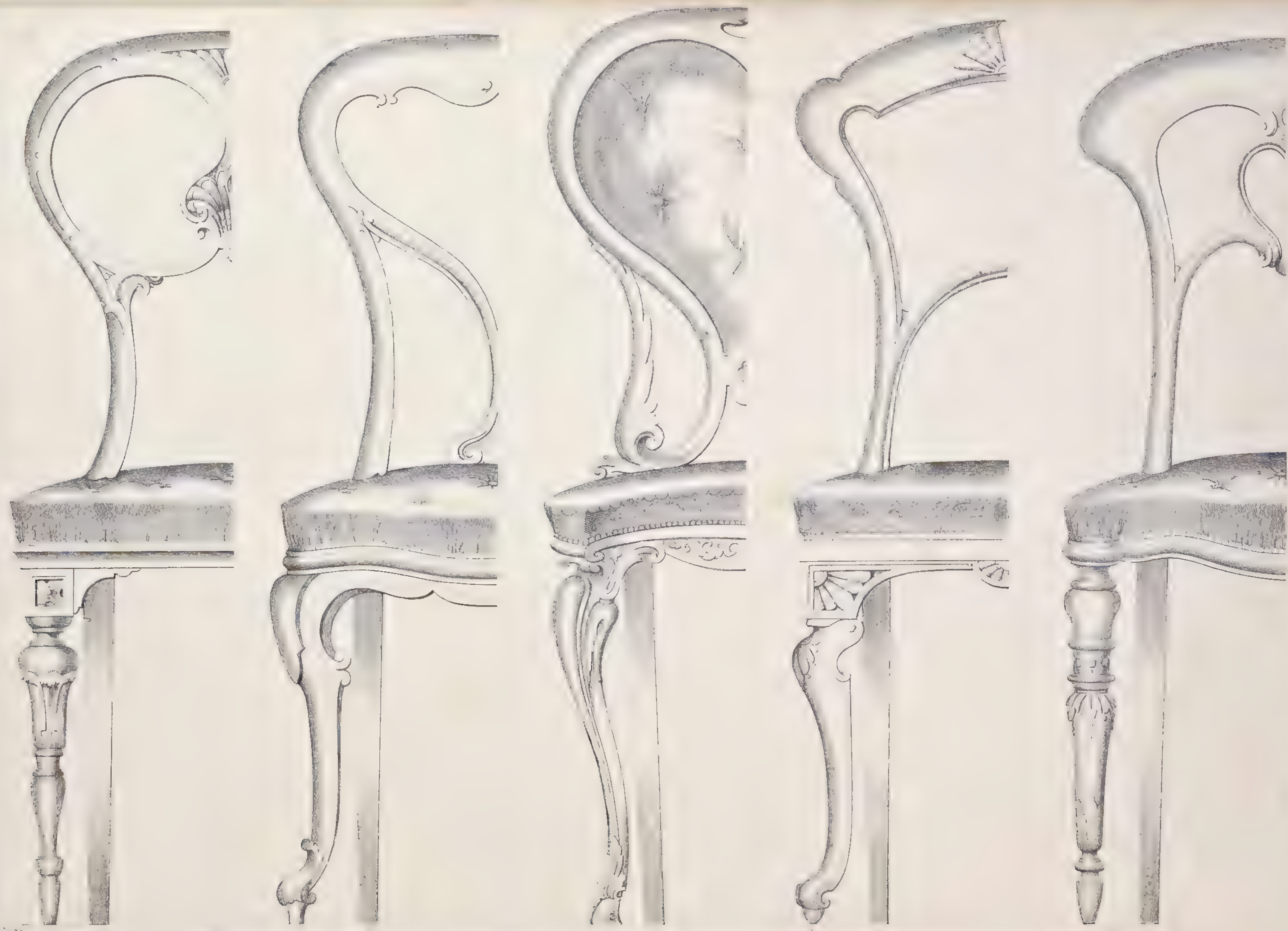
WILLIAM MACKENZIE, GLASGOW, EDINBURGH & LONDON.

SIDEBOARD BACKS

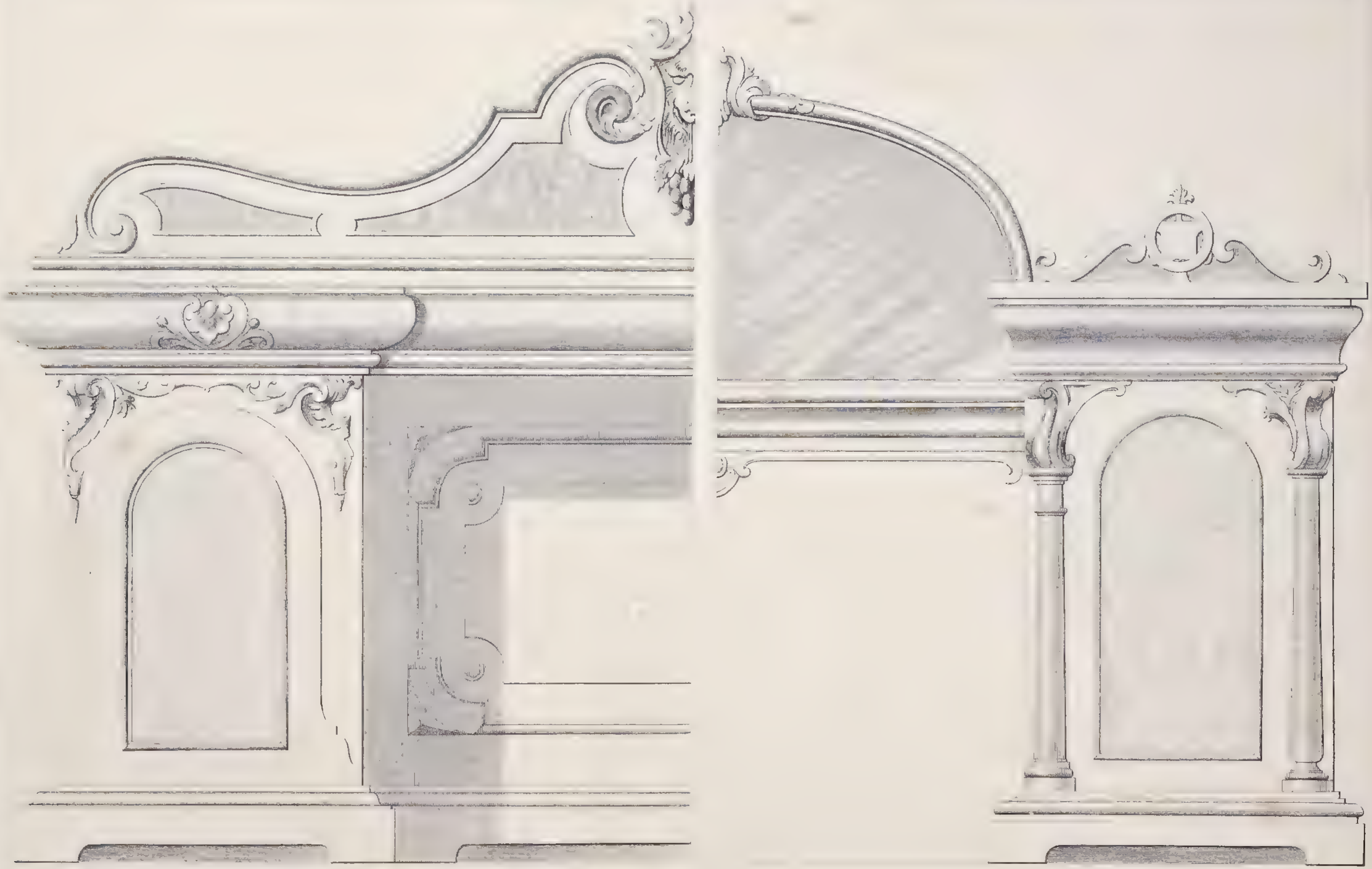


COMMODE FRAMES & DOOR PANELS

BOOKCASE WARDROBE

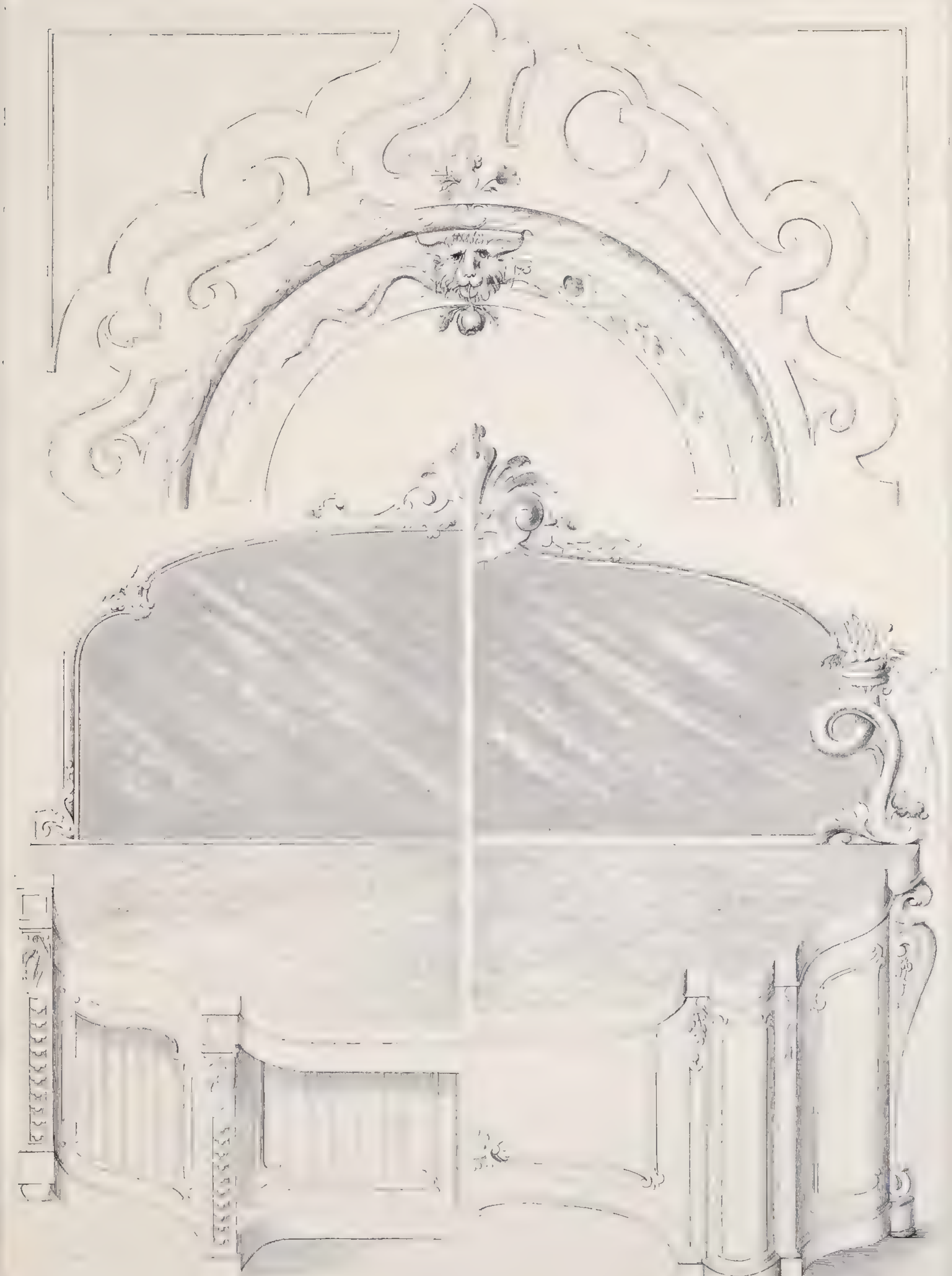


SIDEBOARDS



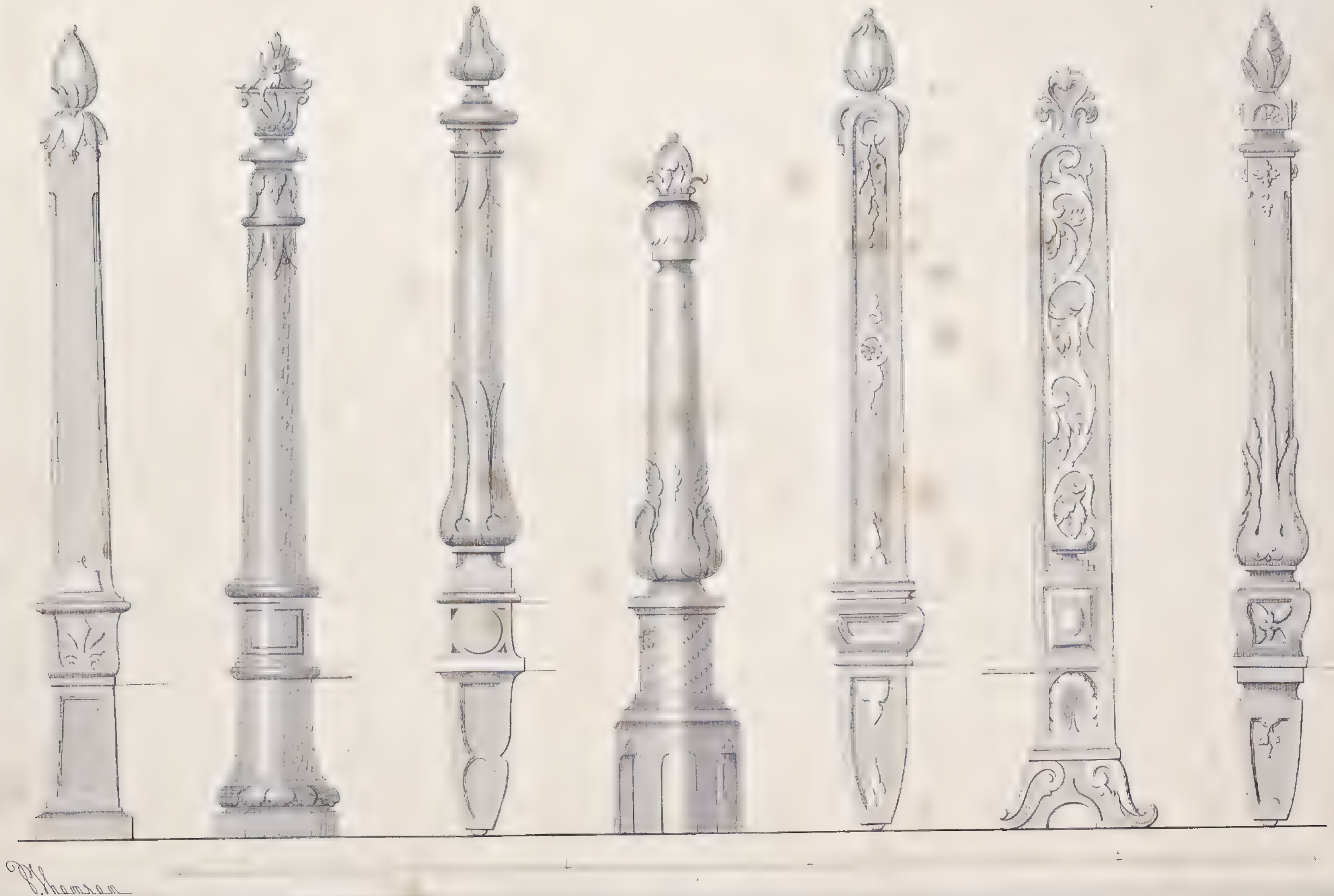
P. Thomson

R. Dawson

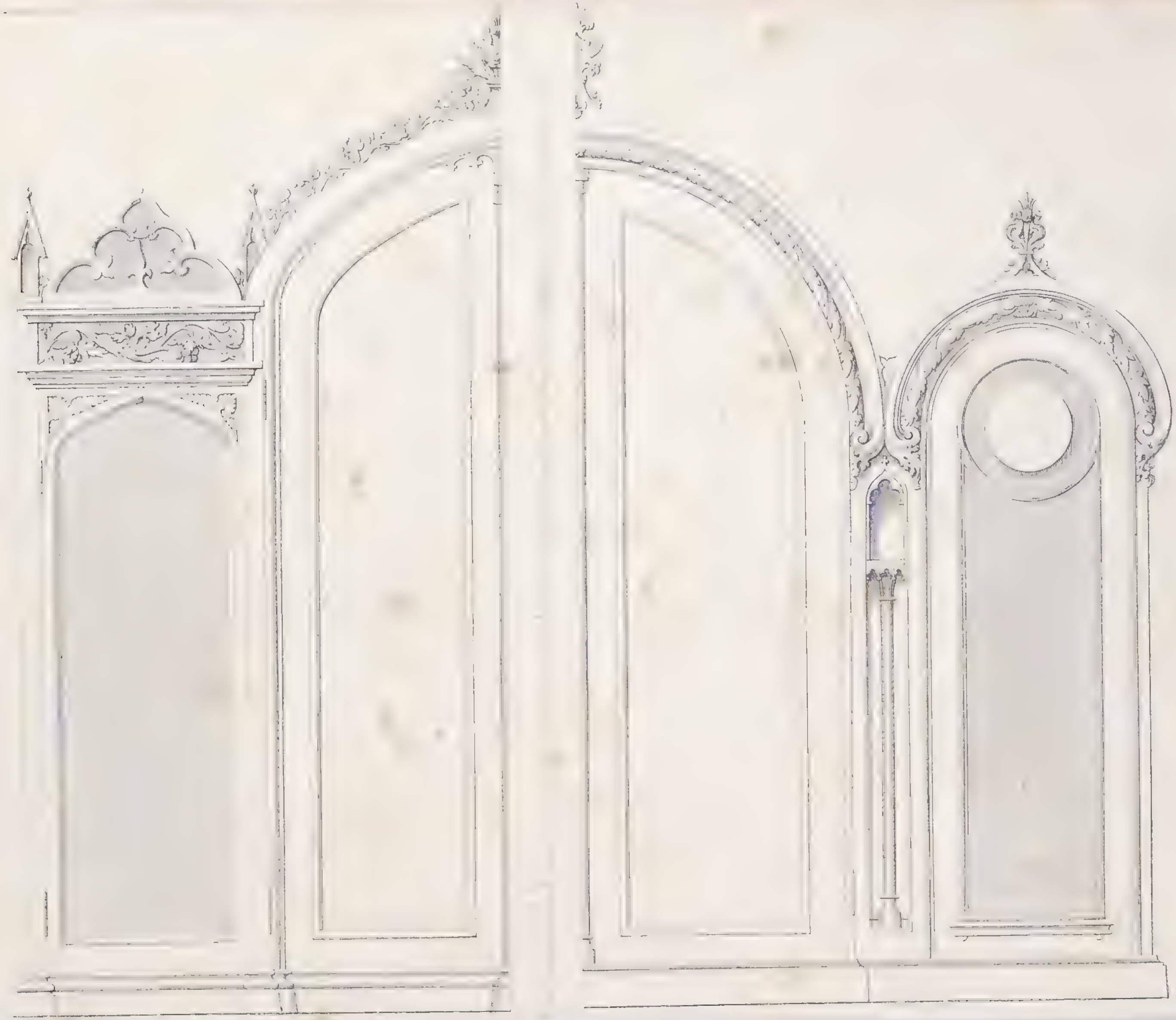


WARDROBE DETAILS

BED PILLARS

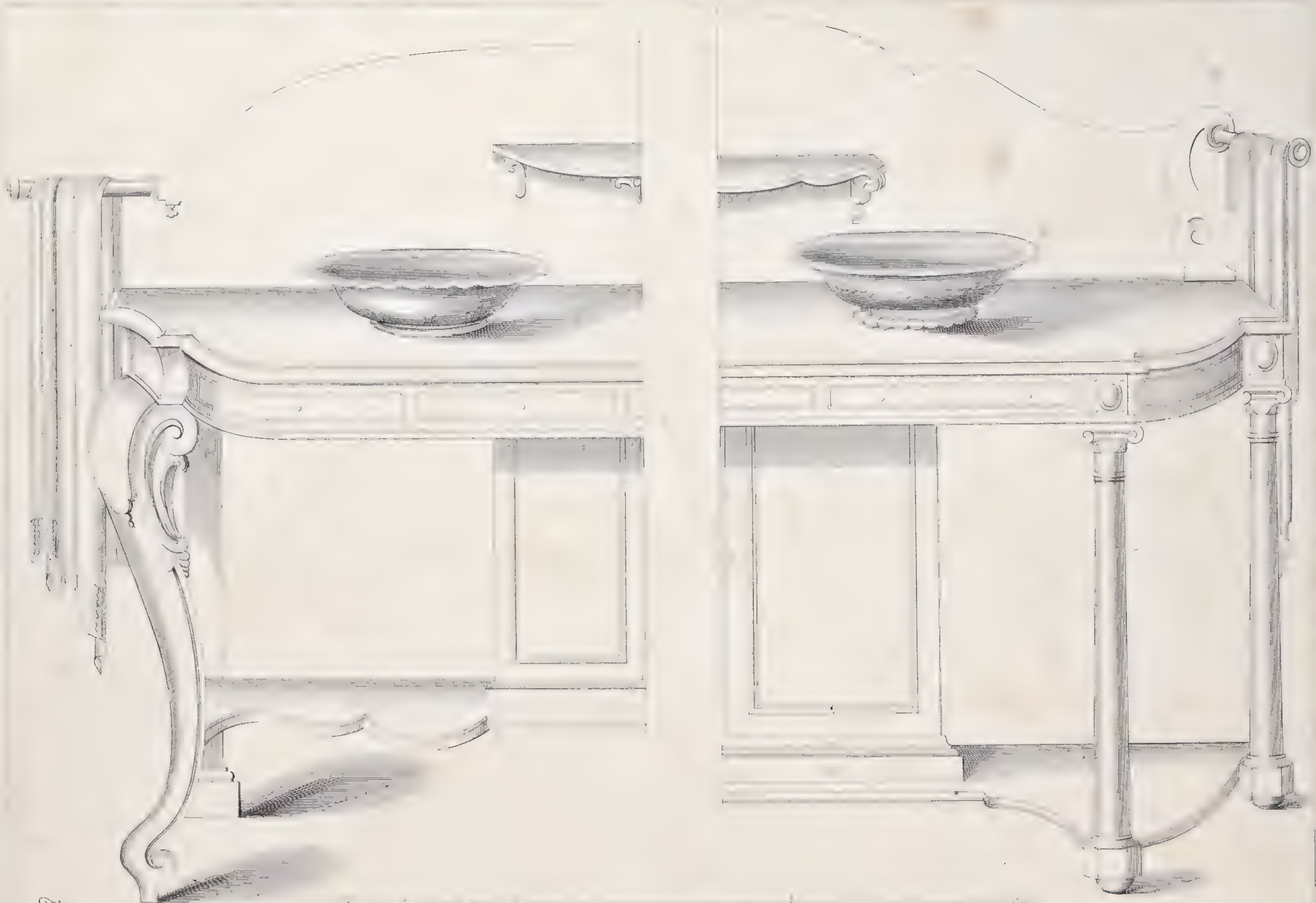


WARDROBES



CABINETS

WASHING STANDS

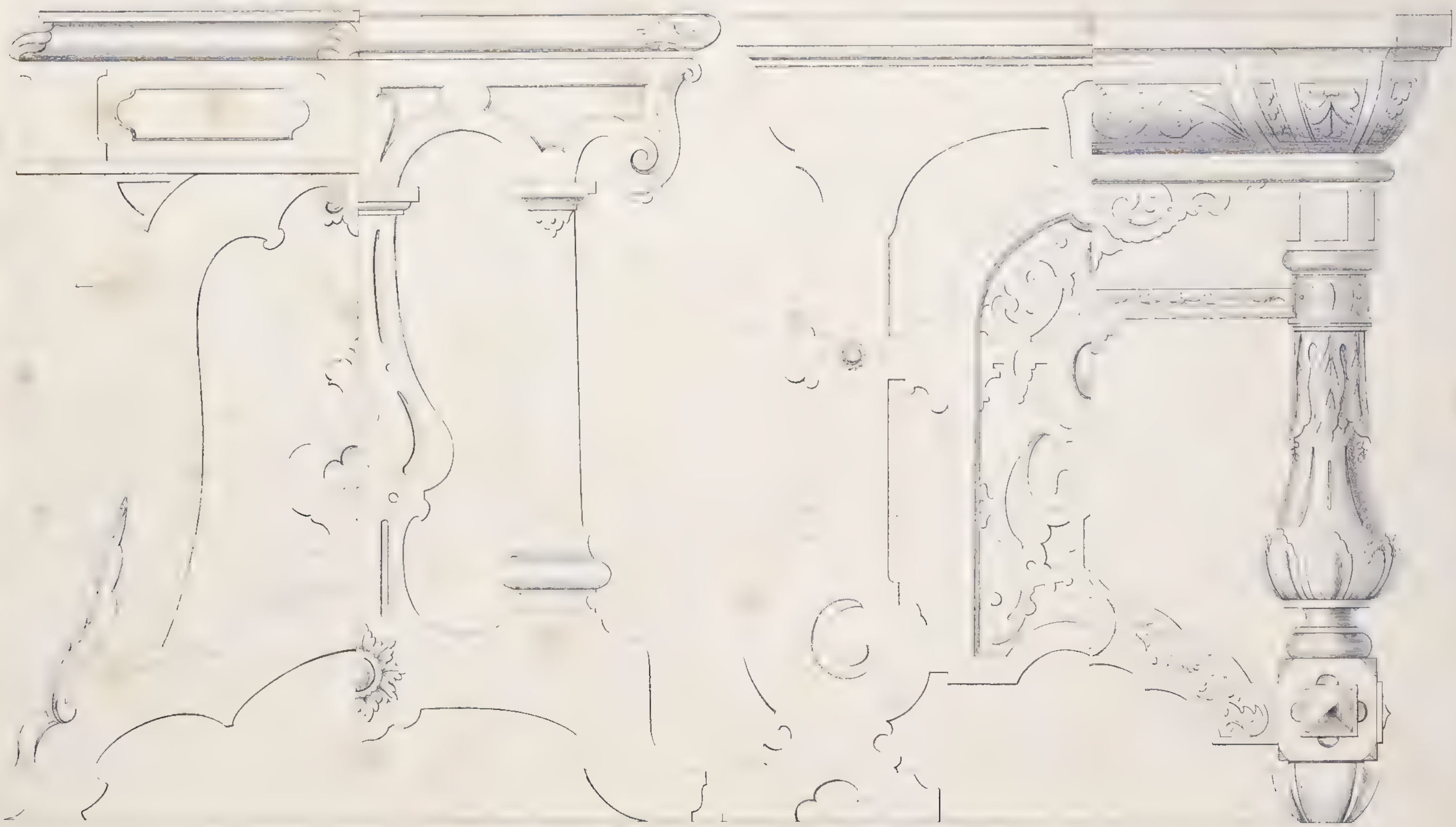


P. Thomson

J. Miller

WARDROBES

LIBRARY TABLE ENDS

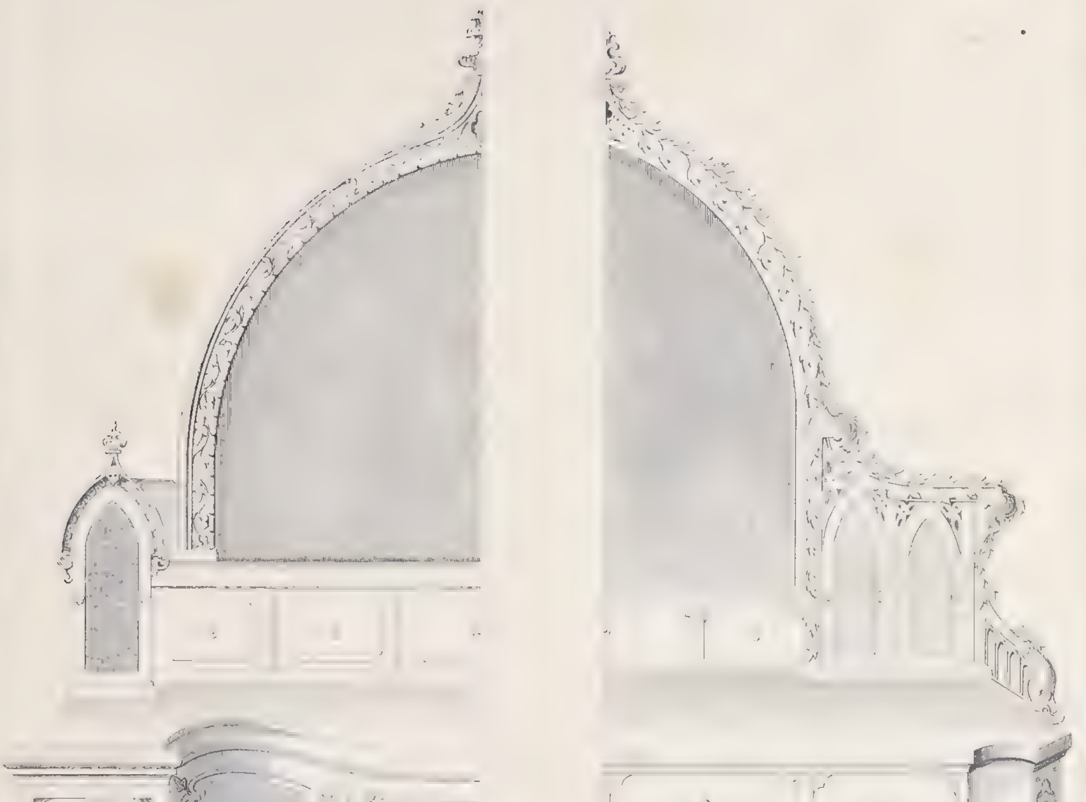


G. Thomson

J. Miller

[illegible] GLASGOW EDINBURGH & LONDON

TOILET TABLES



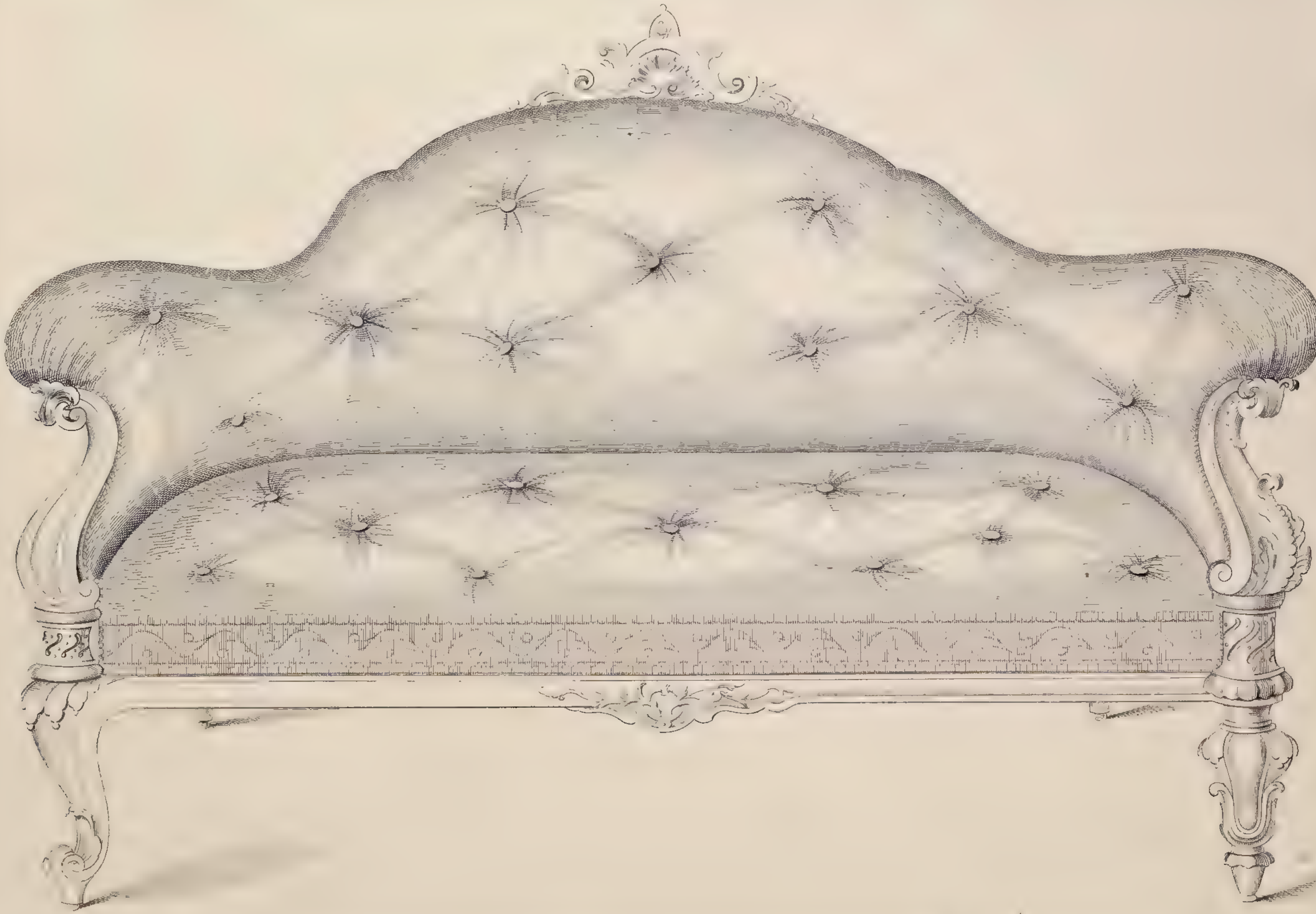
T. Chamran

TRUSSES

CHEVAL MIRROR

PIER TABLE

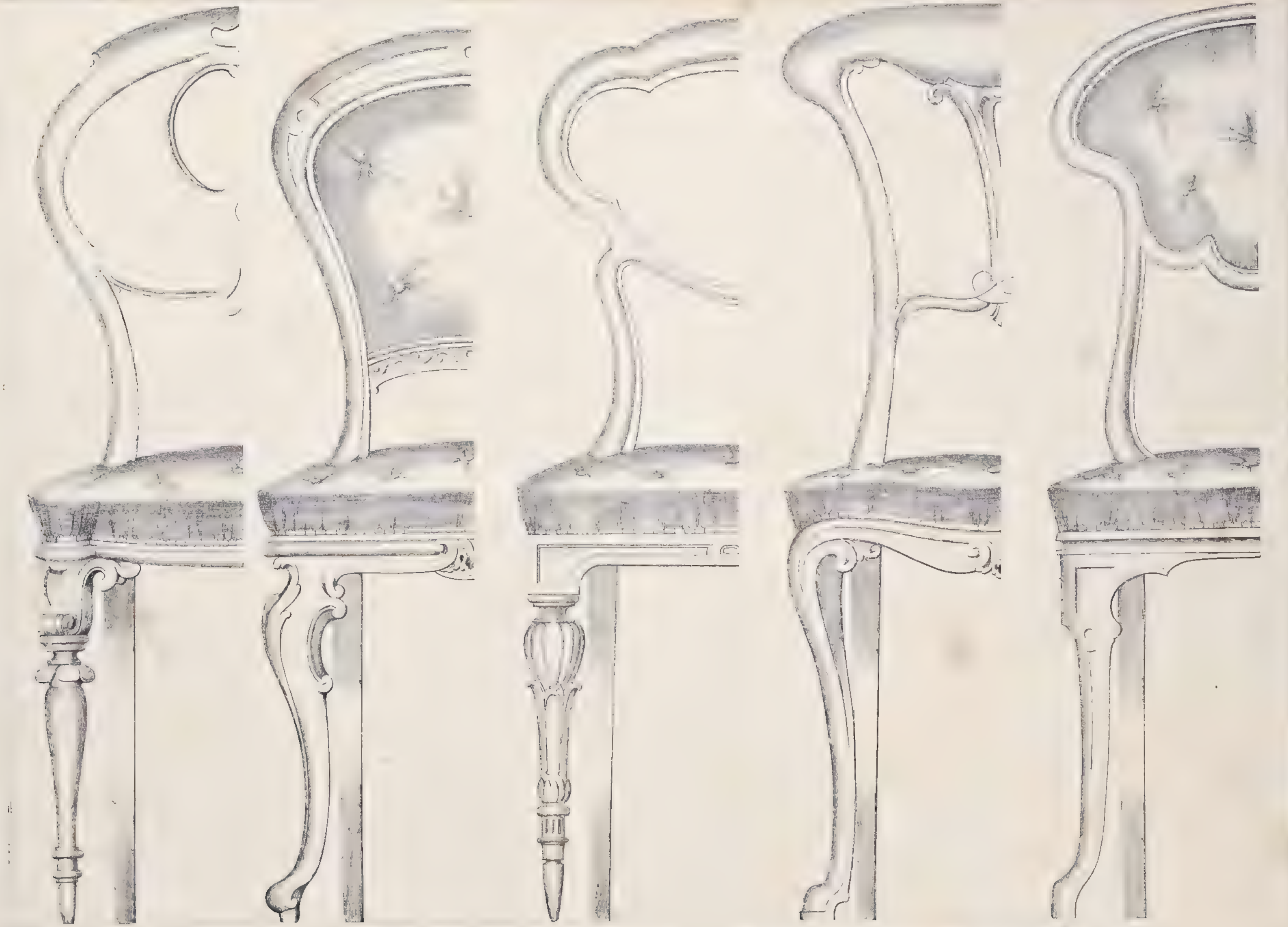
SOFAS



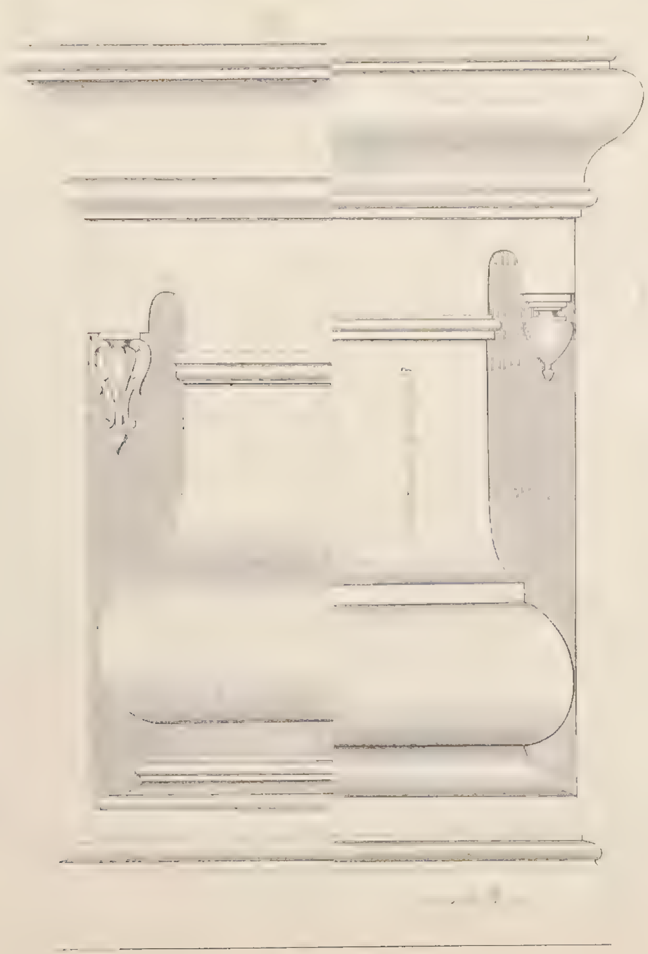
C. Thomson.

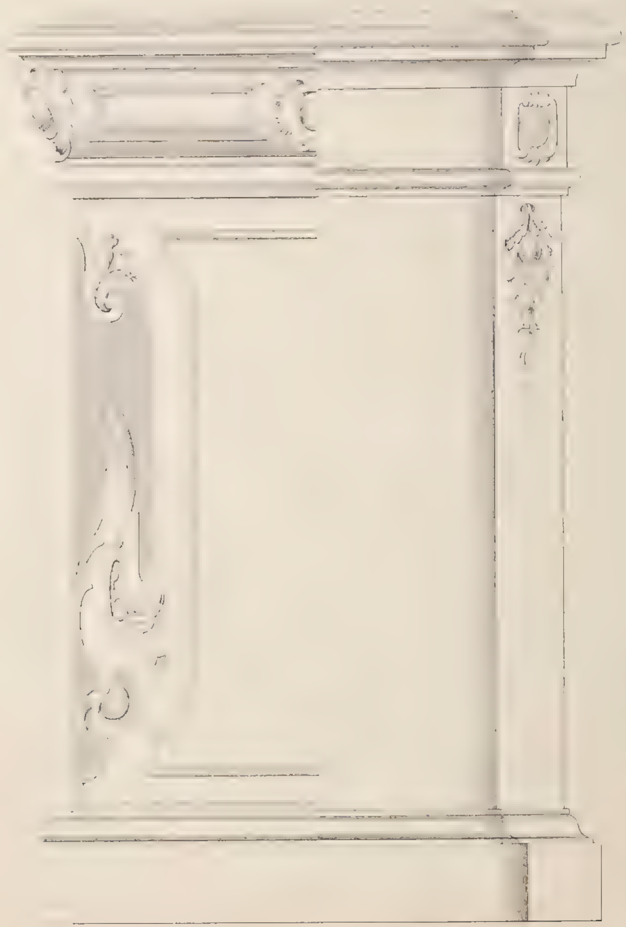
SIDEBOARDS

DINING ROOM CHAIRS

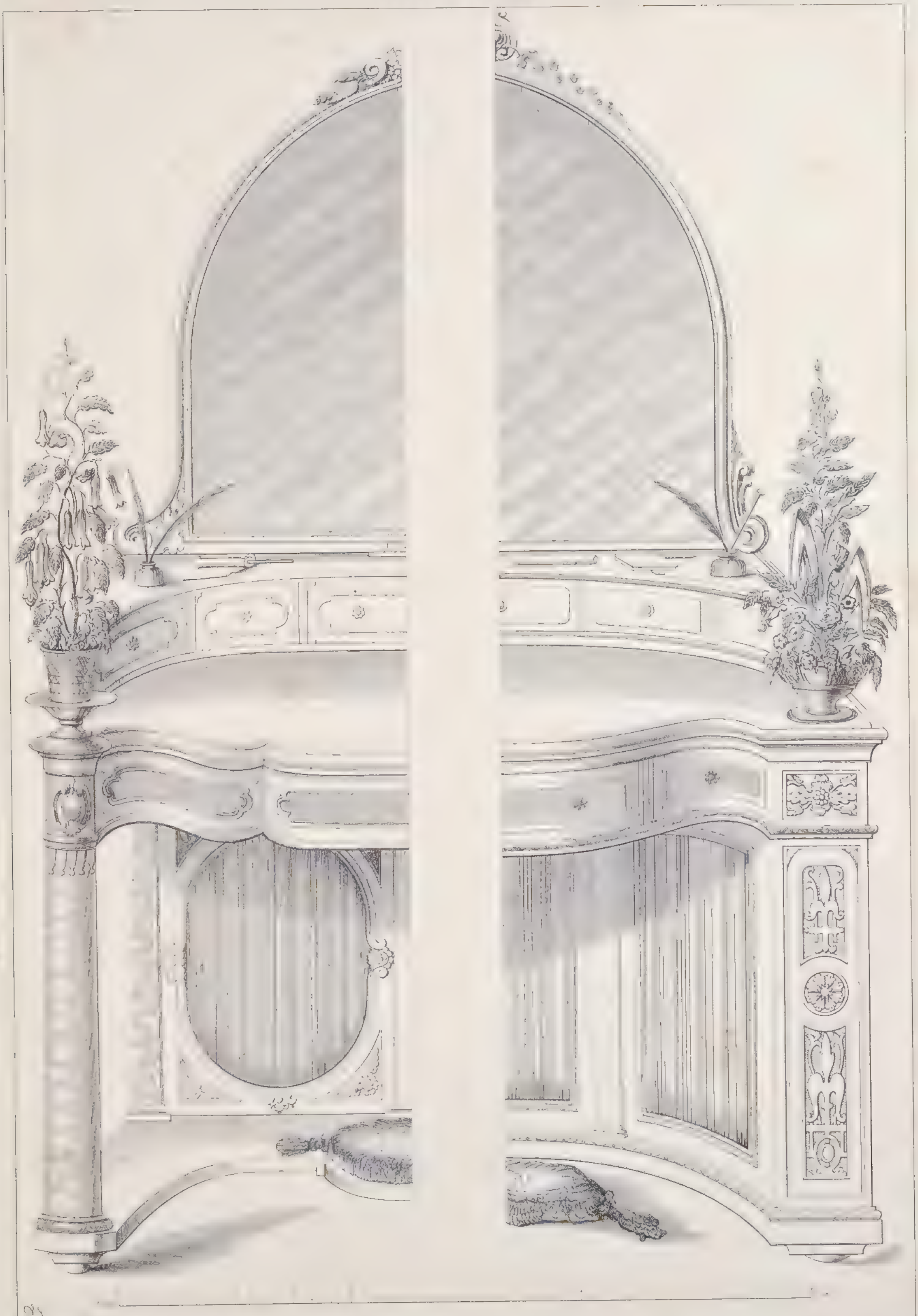


SIDEBOARD DOORS

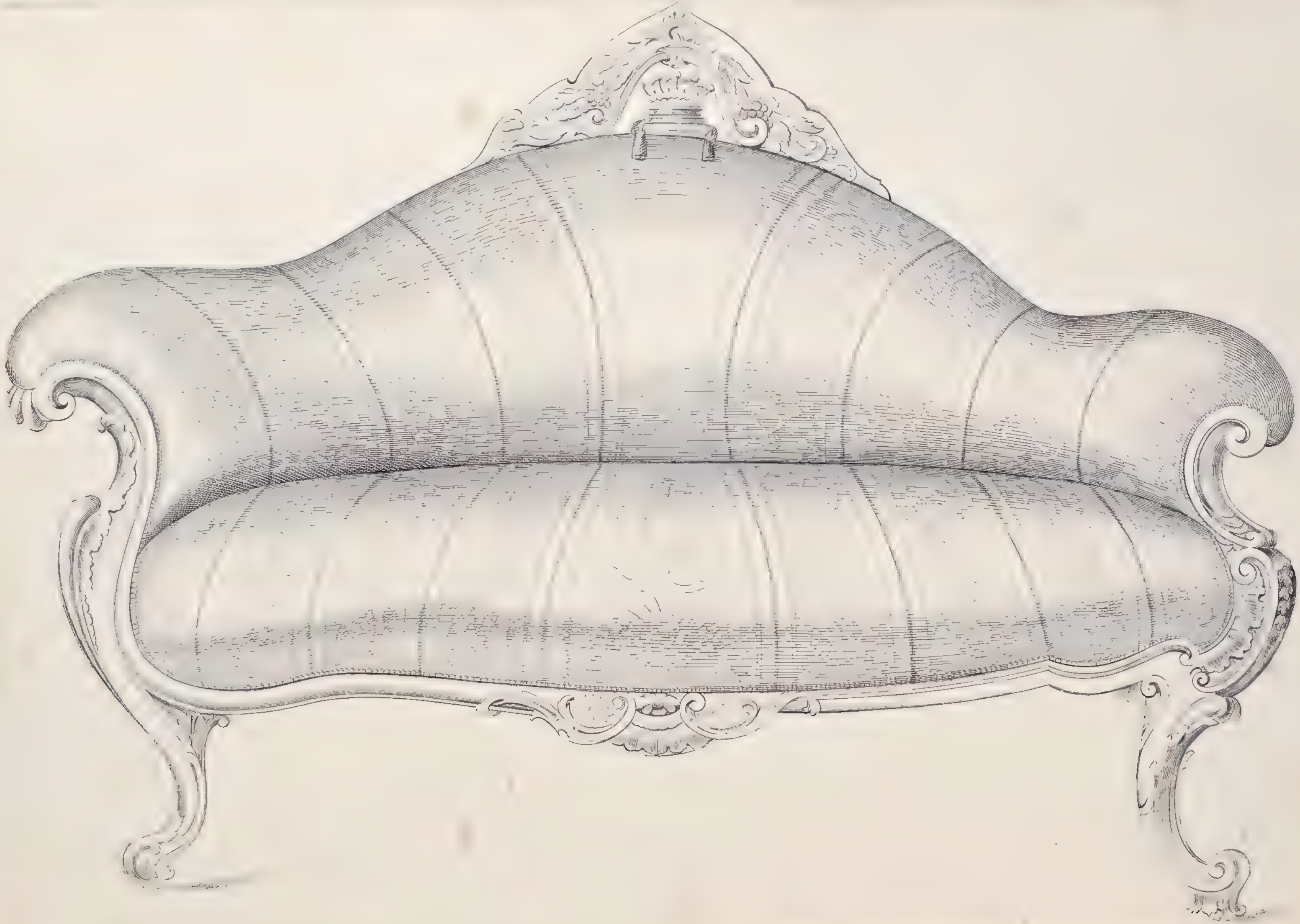




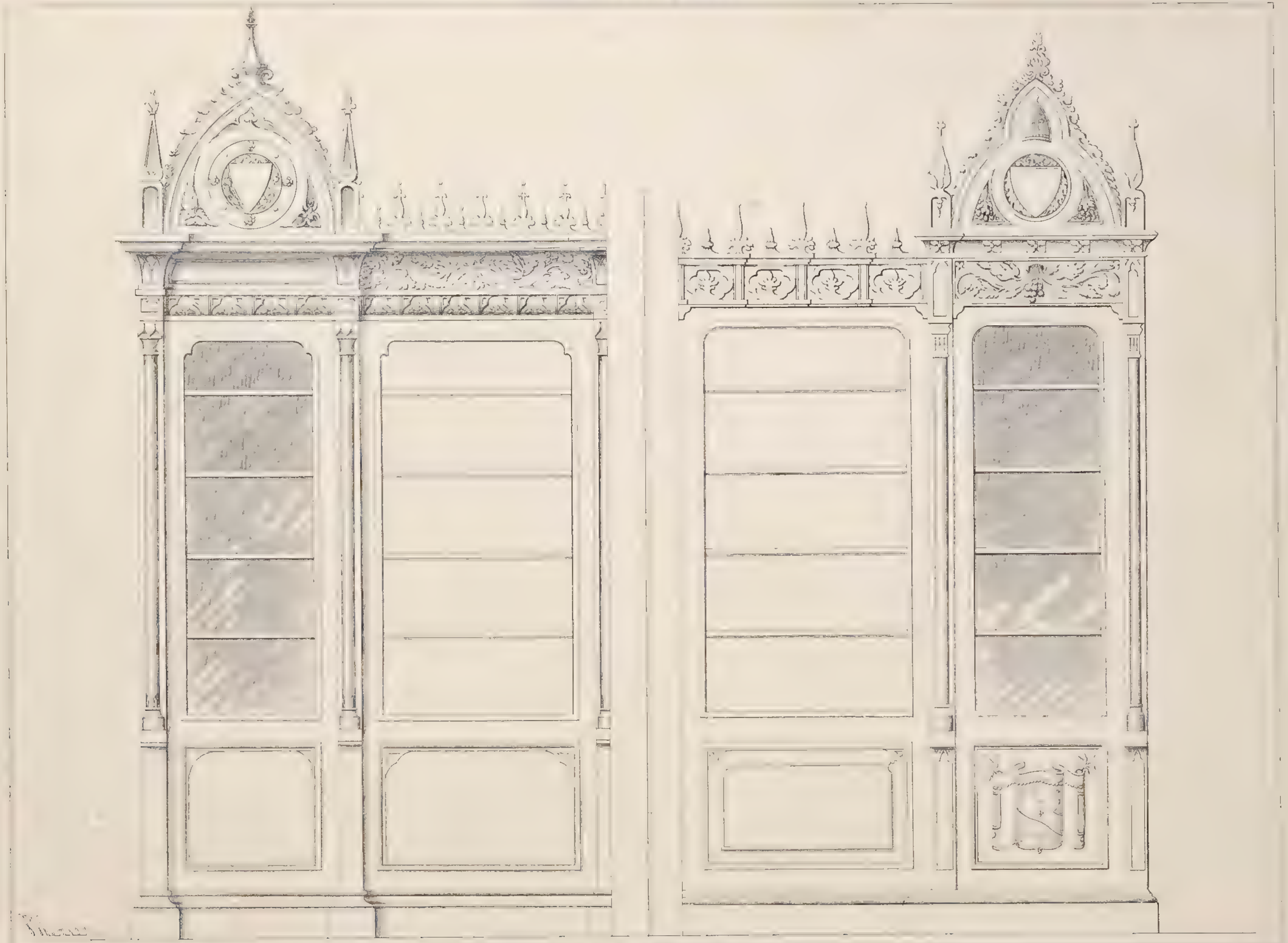
TOILET TABLES



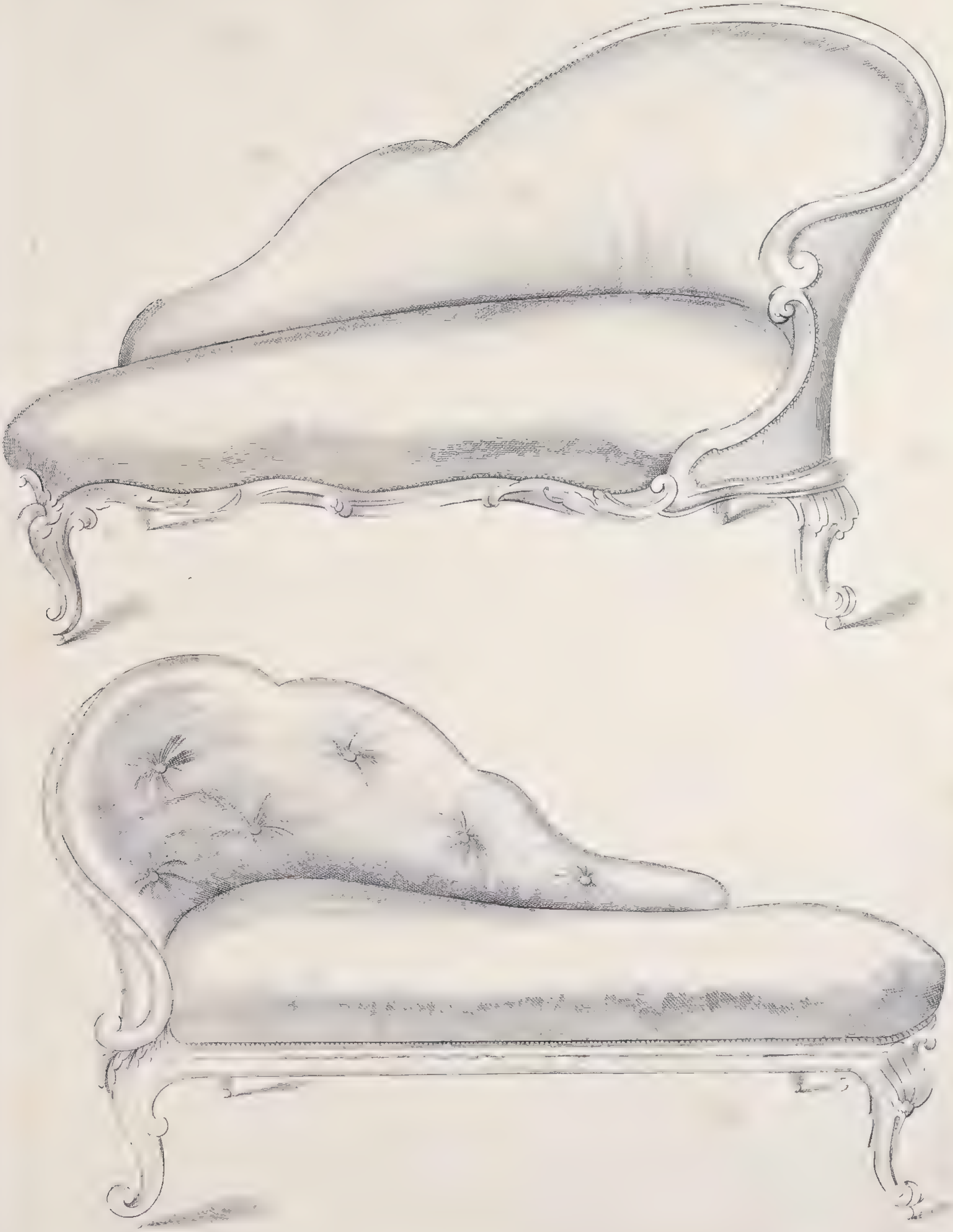
DRAWING ROOM SOFA



LIBRARY BOOKCASE

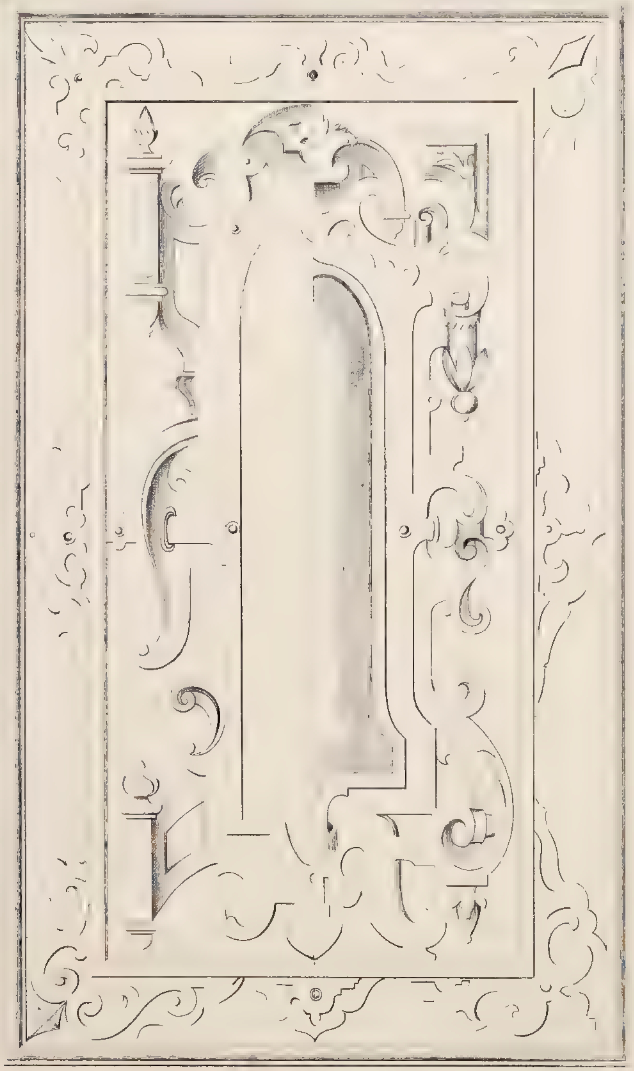


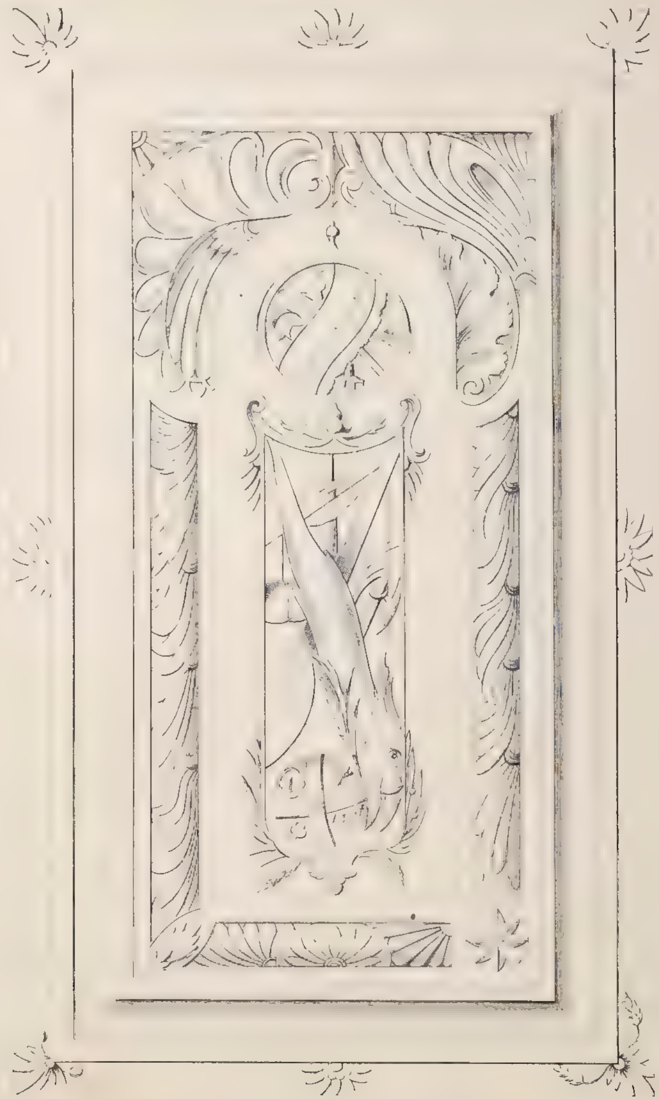
COUCHES



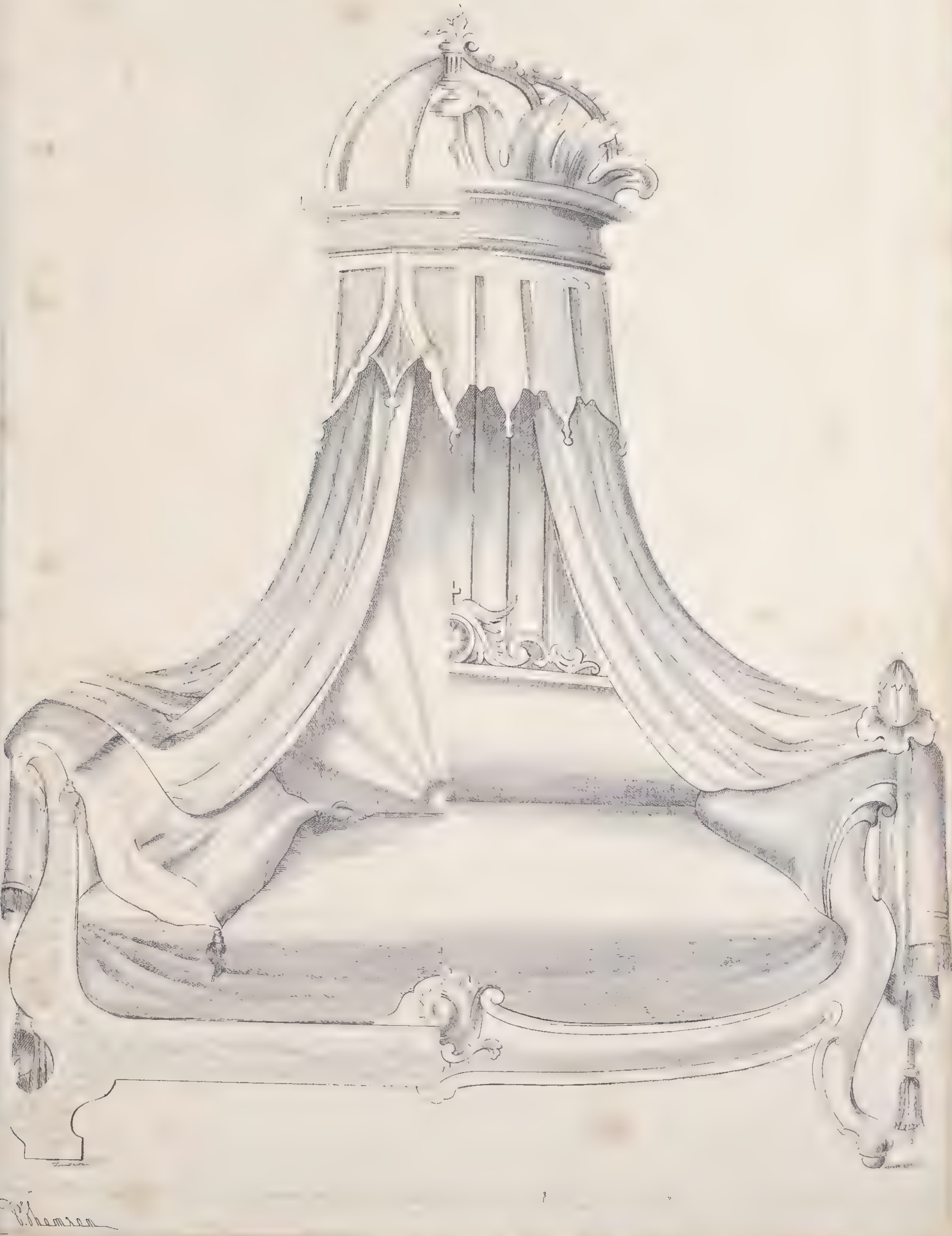
P. Thomson

PANELS



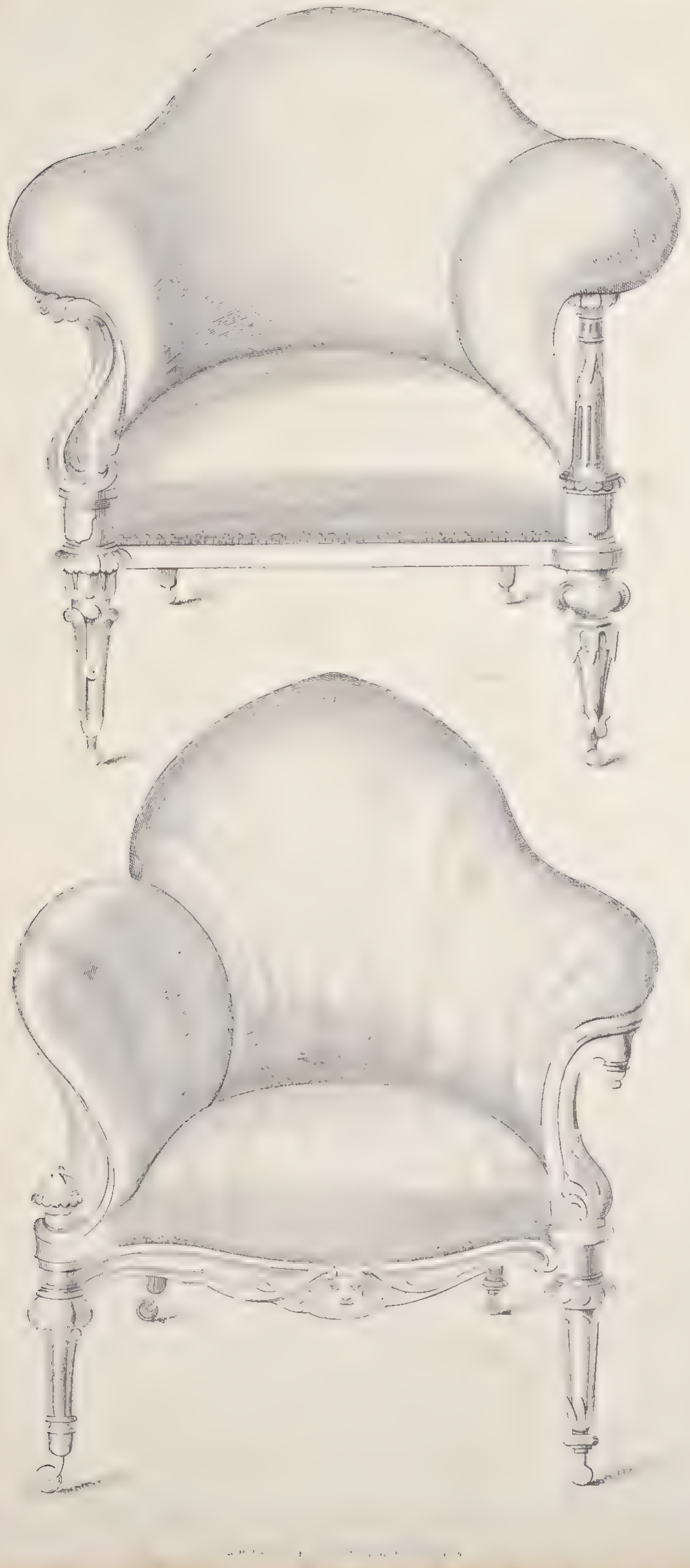


CANDOPY BEDS



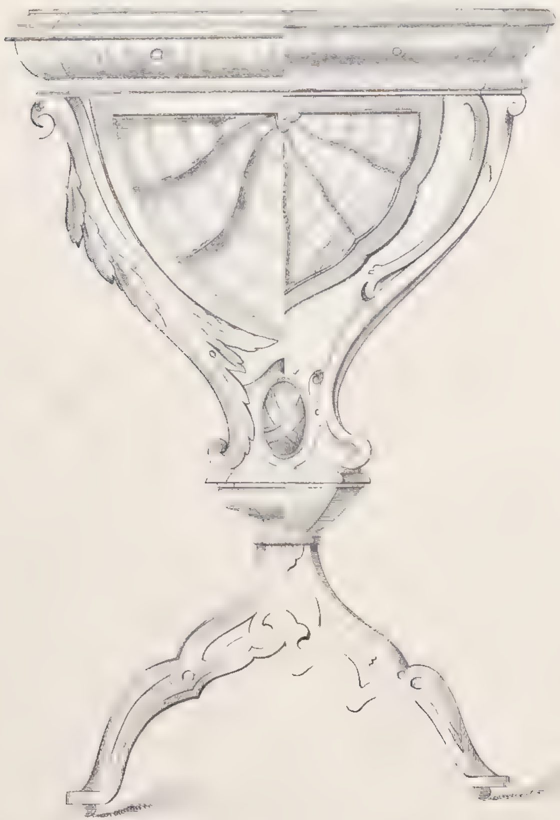
3

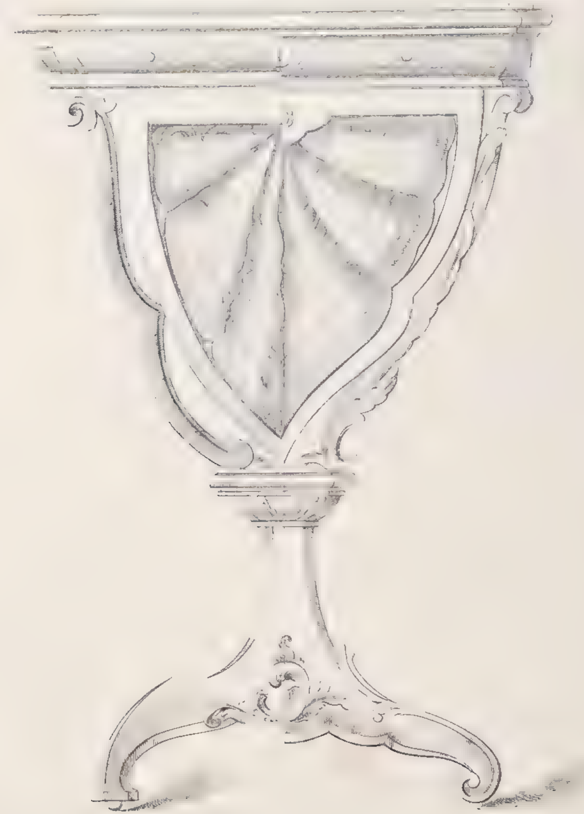
DINING ROOM CHAIRS



G. Thomson

WORK TABLES



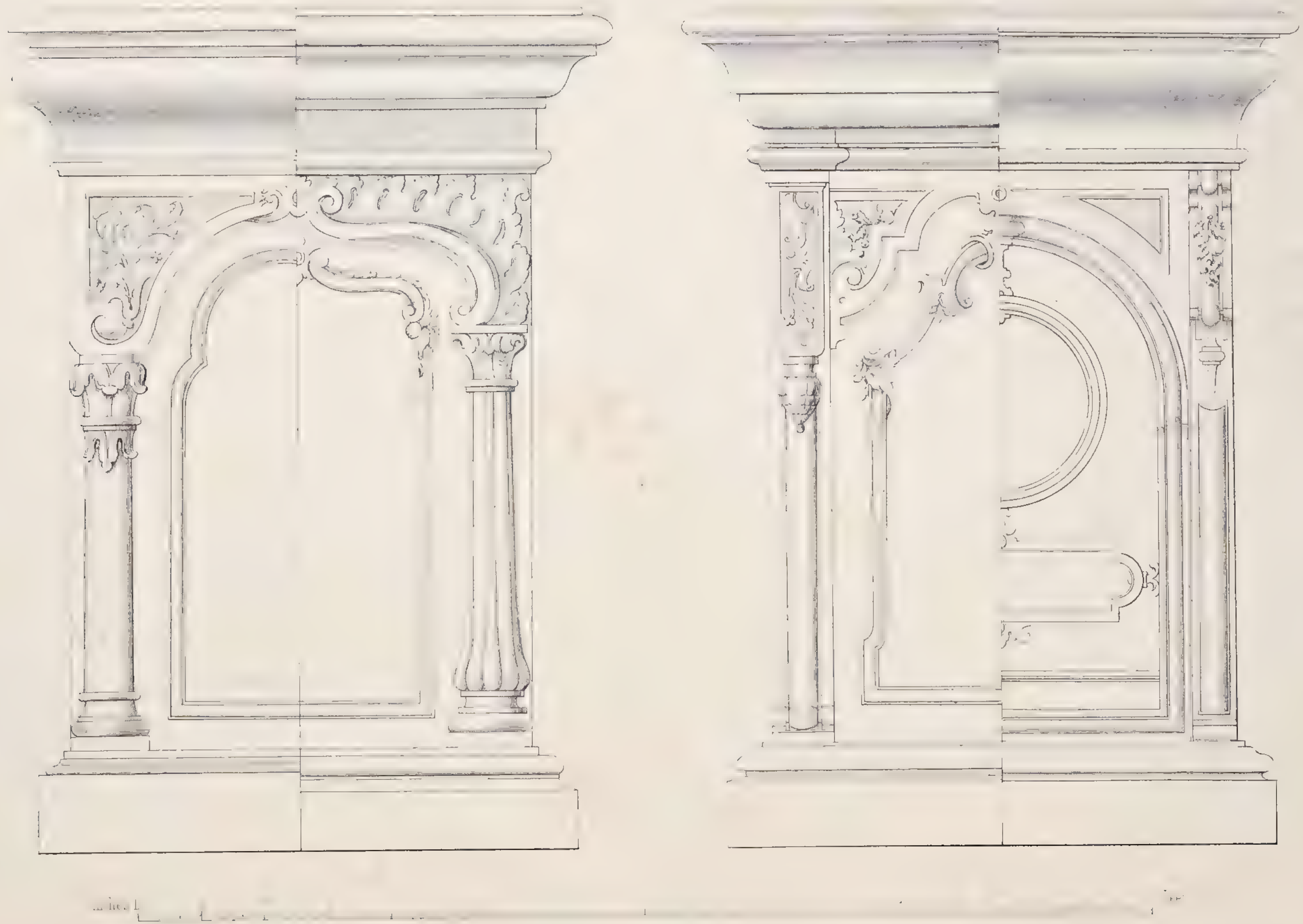


Inches

P. Thomson

Miller

DETAILS FOR SIDEBOARD



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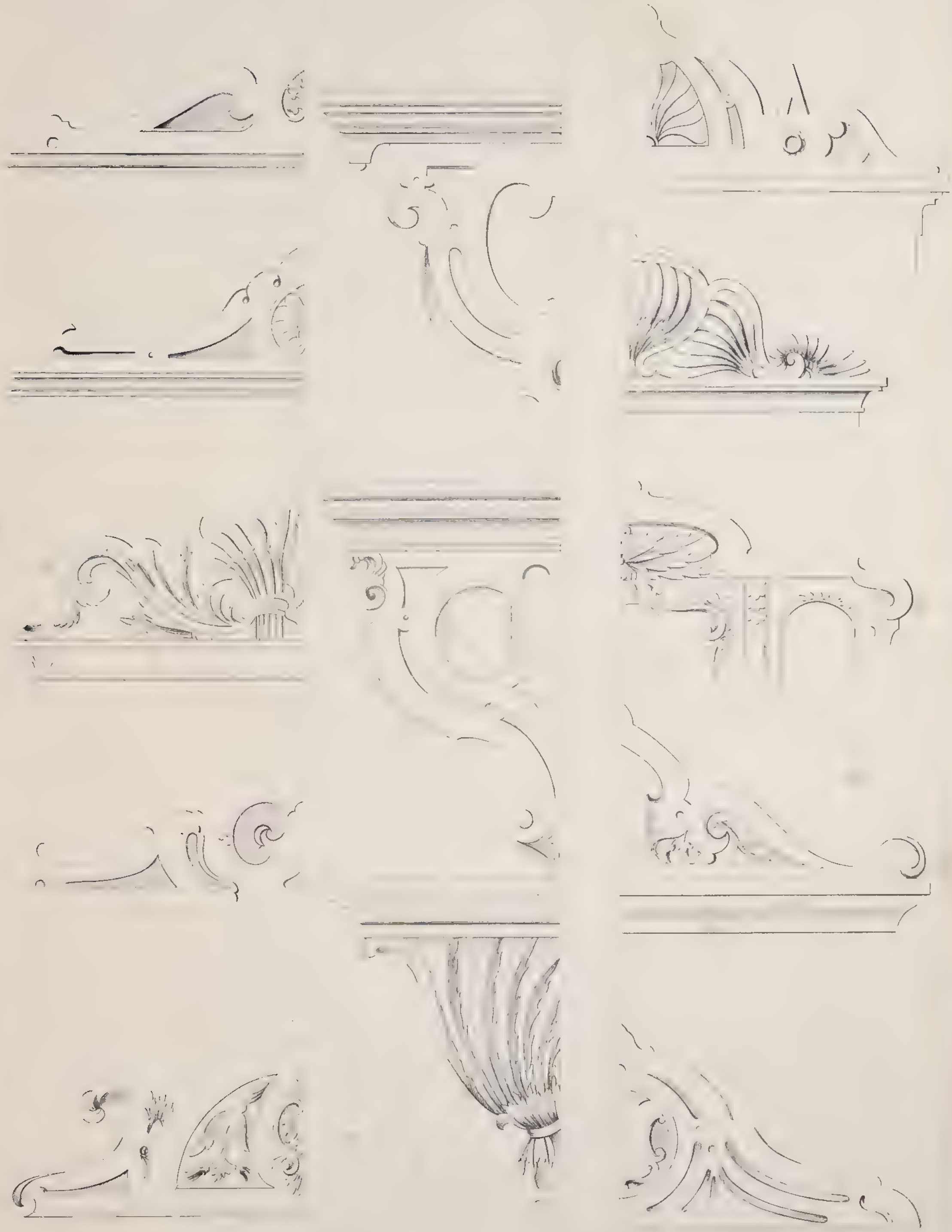
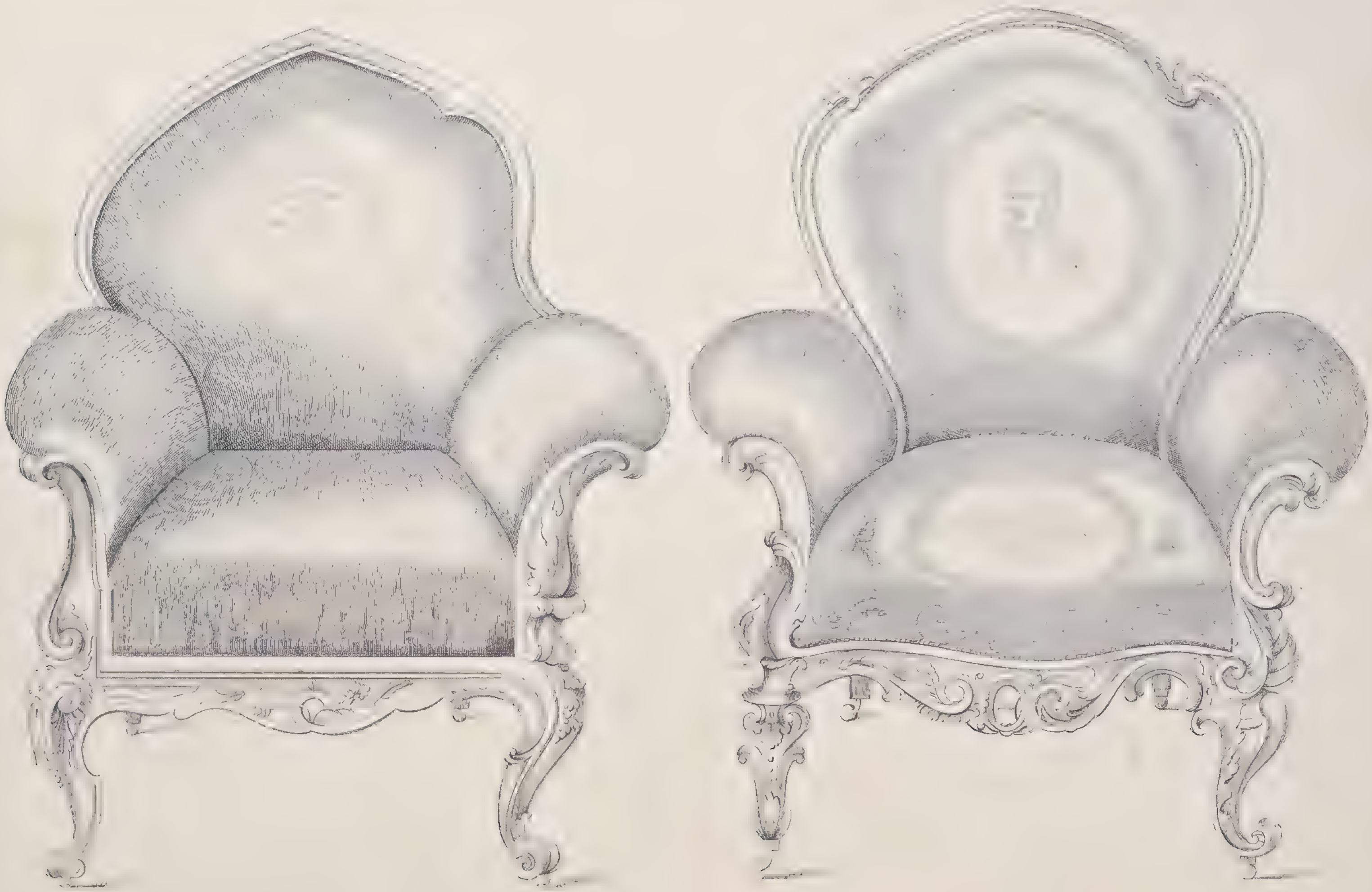
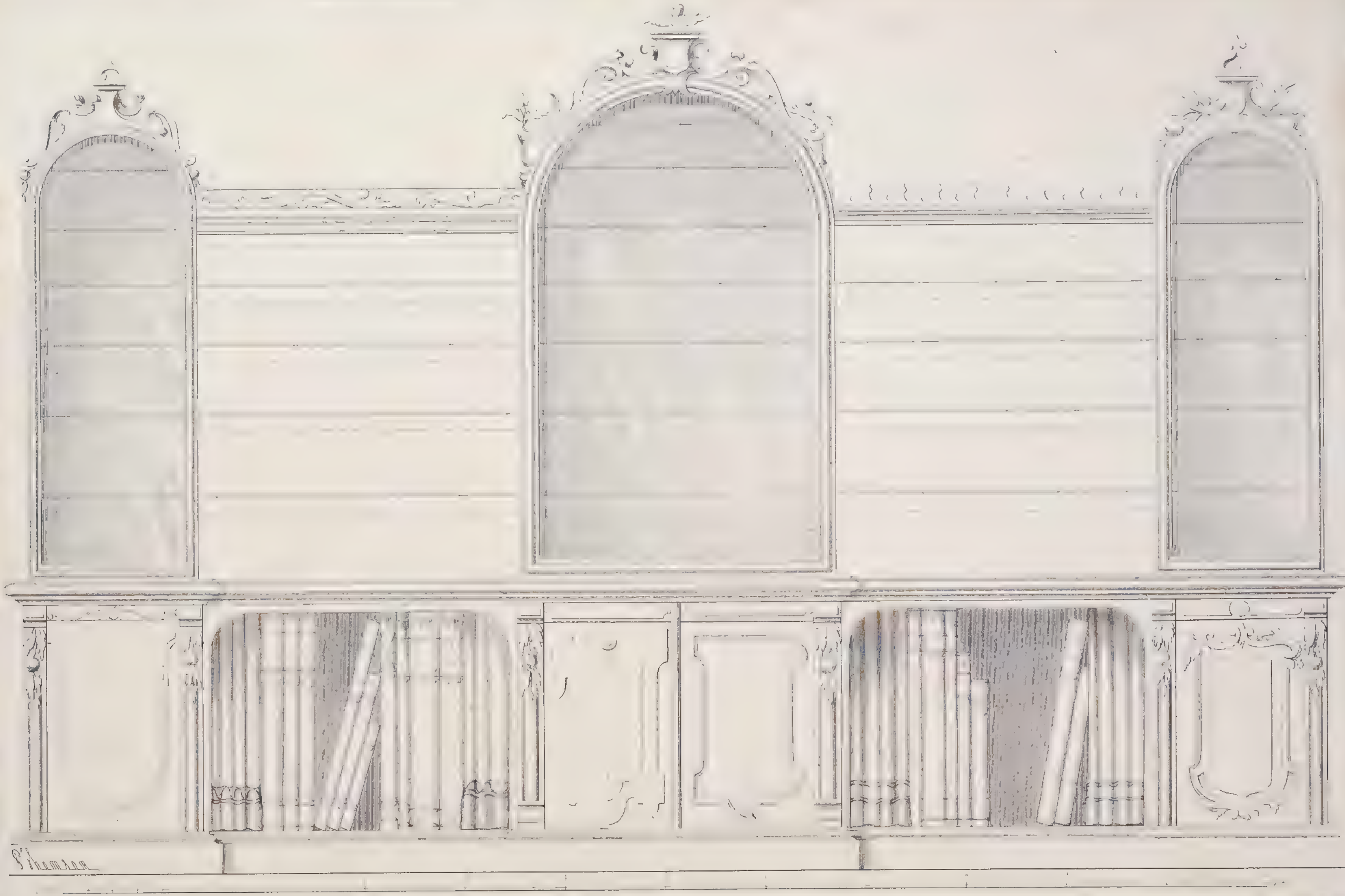
WORK TABLES



EASY CHAIRS



BOOKCASE



SETTEE

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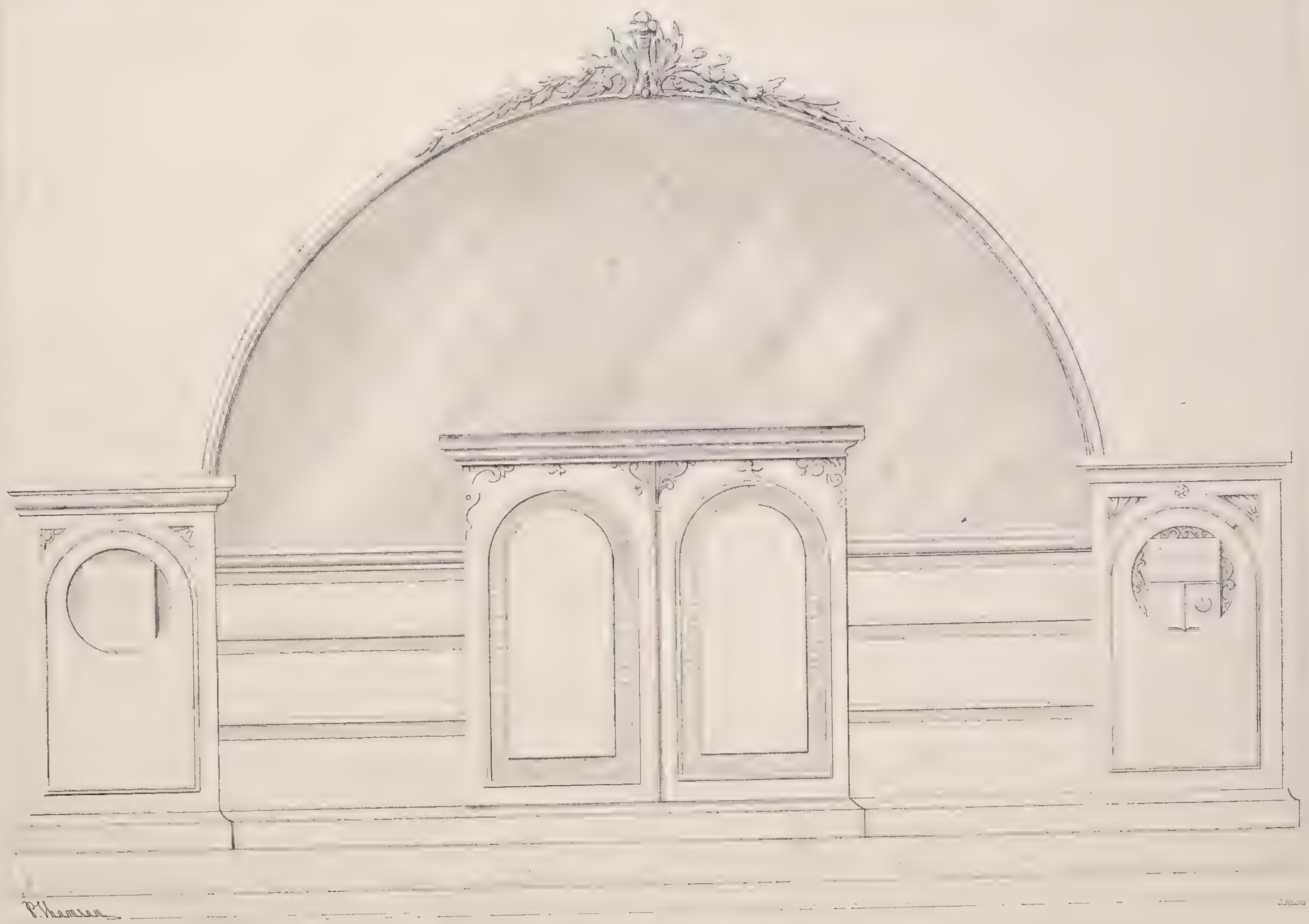
CABINET FOR STUDIO



94 pls